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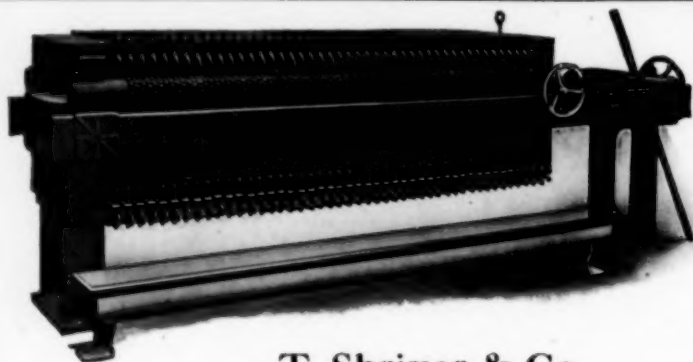
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# Metallurgical and Chemical Engineering

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## The Ways of the Chemists

All roads lead to the Pacific Coast this summer and American chemists and chemical engineers have their choice. The American Institute of Chemical Engineers will meet in Los Angeles on August 18 and in San Francisco from August 25 to 28, the American Chemical Society in Seattle from August 31 to September 3, the American Electrochemical Society in San Francisco from September 16 to 18, simultaneously with the American Institute of Mining Engineers and the American Institute of Electrical Engineers, and during the following week, September 20 to 25, the International Engineering Congress will be held.

If in view of the inherent unity of all chemical endeavor it is an axiomatic rule that meetings of different chemical societies in different cities should not conflict in date, the corollary would seem to be that meetings in the same locality should be held simultaneously and at least in part jointly. Yet here we have a string of Pacific Coast meetings extending over six weeks. Such are the ways of the chemists.

But who should be blamed? Not the chemists in the first place. When the International Engineering Congress was organized the chemists were considered a negligible quantity and not taken into consideration; this was awfully narrow from an engineering standpoint. If the Chemical Engineers and the Chemical Society stay away from the Congress, it is their good right and affords them an opportunity to strengthen their own individuality. On the other hand, the American Electrochemical Society, unafraid of having its individuality swamped, will enjoy intimate intercourse with mining and electrical engineers and its members will be able to attend the International Engineering Congress. The intercourse of ideas should be mutually helpful and should emphasize that after all the idea of chemistry not being a vital branch of engineering is ridiculously out of date.

## The Iron in Lake Ores

A very valuable compilation is annually made by the Lake Superior Iron Ore Association, showing the average iron content, and in some cases also the phosphorus, silica and moisture, in the Lake Superior ores shipped during the preceding season, the Bessemer and non-Bessemer ores of each range being averaged separately. These statistics are carried back to the year 1902. It usually occurs that when one becomes really interested in statistics he desires more, and we confess we should be very glad if these statistics ranged back so that one could note the average iron content in the year when it was highest. We cannot extrapolate, of course, but we may note that from 1902 the average



iron content of all the Lake ores shipped decreased from 56.2233 per cent iron, natural state, to 55.5049 per cent in 1903. From 1903 to 1904 there was an increase of 0.07 per cent, a temporary fluctuation due to the fact that 1904 was an "off" year in iron demand and only the better ores were shipped. In 1905 there was a loss from 1904 of 0.97 per cent, and in 1906 a further loss of 0.74 per cent. Since then the annual losses have been growing less and less, but what the averages were prior to 1902 one can only conjecture.

While the iron content of a given ore deposit is determined by geology, the average iron content of the ores shipped in a season is determined partly by commercial conditions. When demand one year is poor, only the richer ores are shipped, and the average iron content of the season's shipments is certain to show either a gain or a smaller loss than usual. Over a period of years the older and richer deposits are exhausted and other and leaner ore bodies are opened. Of Lake Superior ores there is no end, and while attempts are often made to estimate the total tonnage in the ground of "commercially available" ores one might almost as well essay to determine the volume of a blunt cone without the height being given. As the cutting plane were lowered the volume would rapidly increase.

Of the 1914 shipments the tonnage and average iron content was as follows, low grade, silicious and maniferous ores being omitted from the reckoning:

	Bessemer		Non-Bessemer	
	Tons	Per cent	Tons	Per cent
Gogebic .....	2,067,627	54.4771	1,387,006	53.5142
Marquette .....	380,484	53.9746	1,676,825	53.0141
Menominee .....	59,380	56.9574	2,360,684	51.5970
Vermillion .....	741,224	58.4818	262,946	58.7976
Cuyuna .....			736,573	50.0926
Total old range .....	3,248,715	55.5773	6,424,034	52.5031
Mesabi .....	8,075,955	52.5751	12,726,990	49.5887
All ranges .....	11,324,670	53.3789	19,151,024	50.5663

In 1907 the base guarantees were revised, being reduced from 56.70 per cent to 55 per cent, natural state, in the case of Bessemer ores, and from 52.80 per cent to 51.50 per cent in the cases of non-Bessemer ores. Thus in 1914 the average of old-range ores, Bessemer and non-Bessemer, barely escaped falling below the base analysis, while the Mesabi ores averaged more than two units below the base guarantees, so that as a rule Mesabi ores did not sell in the market for the nominal prices, but had penalties attached.

The cost of making a ton of pig iron has been greatly increased in the past 15 years or so by the loss of so many units of iron, while as a partial offset there have been improvements in processes of manufacture. Freights paid make up so large a part of the cost of assembling the raw materials for a ton of pig iron that the field for refinements in manufacture is limited, for as the iron content goes down, the coke and limestone requirements increase still more rapidly.

While the average iron content of the Lake Superior ores has been decreasing year by year, the cost per ton of mining has been increasing, for the ores must be sought farther and farther underground as the deposits nearer the surface become exhausted. Thus year by year more engineering and metallurgical skill is called for by the iron industry.

### Flotation as a Conservation Measure

It seems reasonably probable that the flotation process will ultimately be recognized as one of the greatest agents in the conservation of mineral resources. While its adoption by American metallurgists has been long deferred, to the surprise of foreign engineers who have known of its success elsewhere for the past decade, it is now springing rapidly into prominence. There is scarcely a mill of major or minor prominence at which the process is not under investigation, provided it seems at all applicable to the ore under treatment.

The conservation of mineral resources, as relating to preventable waste, is one of the most important phases of the whole conservation movement. Forests once destroyed can be replaced in time; impoverished soil can be restored to fertility, and the development of water power and irrigation can sometimes go hand in hand and become permanent agents for good. In ore treatment, on the other hand, particularly in ore dressing, that part of the valuable material which "goes down the creek" as slime tailing is usually forever lost. For this reason any means of preventing such loss is a true agent for conservation, and in this realm flotation shines as a brilliant achievement and promise. It is to-day the accepted method of slime concentration for certain ores.

Flotation on a commercial scale was first applied in this country by Hyde on the Butte & Superior zinc ores. Prior to the use of flotation at Butte & Superior, zinc recovery was roundly 60 per cent. For the year 1914, with flotation in use, the average recovery was 88.71 per cent, and in the first quarter of 1915 it was 91.32 per cent. Coincident with the higher recovery came an increase in the grade of concentrates. This increase in recovery from 60 per cent to 90 per cent, or roughly one-third of the present figure, was due largely to the use of flotation. In 1914 Butte & Superior produced zinc at the rate of 15 per cent of the entire zinc production of the United States, and if flotation is to be credited with one-third of the output, we see that at one mill only, flotation was responsible for the production of about 5 per cent of the total zinc output of our country. These are impressive figures, and they emphasize the importance of flotation as a measure of conservation.

The prospective results from flotation in copper concentration are equally tremendous. As shown elsewhere in this issue, the recovery of copper in 1914 at five of the large western "porphyry" copper properties ranged from 66 per cent to 70 per cent. These results were obtained by ordinary methods of wet concentration without flotation. At Inspiration, on the other hand, where flotation plays an important part in the milling scheme, the recovery from sulphide ore in the experimental mill last February was 90.3 per cent, or from 20 per cent to 25 per cent greater than at the five properties mentioned above. Inspiration has been experimenting with flotation since January, 1913, at which time no copper ore was being treated on a commercial scale by flotation in this country. The process has been developed to a point where a combination flow-sheet has been



adopted for the mill now under construction, which will have a daily capacity of 14,400 tons. Production is expected to commence in June.

The results obtained at Inspiration are at least suggestive of the improvement that will be made at other mills treating similar ore, and in which slime concentration has been effected on vanners. Flotation is undergoing experiment at these mills, and may be expected soon to augment the output of copper. If results can be obtained comparable to those at Inspiration, the percentage recovery will be raised from 65 per cent or 70 per cent to about 90 per cent. The Utah, Ray Consolidated, Nevada Consolidated, Chino and Miami copper companies produced last year a total of over 321,000,000 pounds of copper, operating at greatly reduced capacity for five months of the year. Their aggregate ore reserves amount to over 585,000,000 tons of ore, containing an average of perhaps 1.6 per cent copper. If the application of flotation in the treatment of these ores should mean an increased recovery of 15 per cent or 20 per cent, the net increase looms large indeed. It is true that a part of the tonnage mentioned contains some carbonate ore, and on this portion the recovery would be necessarily lower than on straight sulphide ore; but methods have been suggested and may be successfully applied to render carbonates amenable to flotation.

The foregoing relates only to a few of the largest and most important producers of zinc and copper, because they afford an opportunity to gauge the influence of flotation in the future. Added to these, it must be remembered, will be the numerous small producers scattered throughout the West, to whom flotation will bring an even greater measure of conservation, with attendant profit. It must be obvious that on the settlement of pending litigation over flotation patents, the process will receive an impetus that will reveal its true influence and claim for it the recognition it deserves.

### Spelter and Other Coating Metals

On Tuesday, May 12, the prices of tin, lead, and spelter stood in a relation that had never before obtained in the history of the metal market. The cost of the terne mixture used in making terne plate was less per pound than the price of spelter. Tin was 38.50 cents, New York, and lead 4.20 cents, making a 70 per cent lead and 30 per cent tin mixture cost 14.49 cents, while spelter at St. Louis was 15 cents. Never before had the terne mixture been cheaper than spelter. The lowest annual prices of both tin and lead fell in 1896, tin being 13.24 cents and lead 2.98 cents, making the value of a 70-30 mixture 6.06 cents. In the same year spelter averaged 3.80 cents, or 63 per cent as much, and 1896 was not spelter's lowest year. Incidentally the same day, May 18, was memorable for spelter in that the metal reached a price precisely double the highest price ever attained prior to the recent rise. That high point, 7.50 cents, was reached in September, 1912.

Everyone now understands that the phenomenal advance in spelter is due entirely to the war, first because the war largely increased the demand for brass for

cartridges, and second because the war shut off the exports of spelter from Belgium and Germany. The net effect upon copper produced by the war has been very much less marked, for while the demand is increased the American copper exports that formerly went to Germany have been shut off.

What level the spelter market may attain no one can venture to predict, for when once a market transgresses its former bounds precedents become practically valueless. There is no reason to assume that the recent advance represents only a temporary rise, for purchases of spelter have lately been made, at the high prices, for deliveries late in this year and even in 1916.

With this complete dislocation in the relationships between the costs of the different coating metals, the whole matter of the consumption of metal-coated steel is opened. Spelter for coating purposes may indeed become altogether unobtainable, and in any event the relative costs of metal-coated steels are entirely altered. In 1913 there was produced 808,818 gross tons of galvanized iron and steel sheets, chiefly steel, and 66,664 tons of formed products galvanized after forming, making a total of 875,482 gross tons. It is probable that for a large part of this material substitutes will have to be found. Naturally the preference will not run to the same substitute for all purposes. For roofing purposes the various prepared roofings, which in the past few years have made large inroads on the galvanized sheet roofing trade, will doubtless be more largely employed. Painted steel sheets may be employed for this and other purposes.

For a number of uses tin plate will prove an excellent substitute. The average price of tin the past month has been somewhat under 40 cents, but 40-cent tin as a coating metal is vastly cheaper than 15 or 20-cent spelter, because tin is readily applied at the rate of somewhat less than two pounds per base box of tin plate, 31,360 square inches, or a trifle less than 0.15 oz. per sq. ft., whereas for 28 gauge galvanized sheets almost 1.5 oz. spelter per sq. ft. is required. With 40-cent tin and 20-cent spelter the tin coating could be made five times the minimum and yet leave the cost of the coating metal per square foot the same, producing for certain purposes a vastly superior article. With terne plate the comparison is naturally much more favorable, lead being only a trifle more than one-tenth as costly as tin.

Some of the sheet galvanizers, in order to preserve at least part of their trade, are now disposed to turn to the lead-coated sheet. At various times in the past efforts have been made to place a lead-coated sheet on the market, but very indifferent success has been met. The conditions are now quite altered. The manufacturer can now afford to expend more money and effort to secure a satisfactory product, and the user can afford to pay a higher price. It is already known that two sheet mills in Ohio intend very shortly to place a lead-coated sheet on the market, as a substitute for the galvanized sheet they have been selling and are still endeavoring to sell, and information that may lead to the production of a more satisfactory lead-coated sheet than has yet been made is certainly at a premium.

## Readers' Views and Comments

### Rapid Analysis of Bearing Metals and High-Copper Content Alloys

To the Editor of Metallurgical & Chemical Engineering:

SIR:—The author has found that the well-known method of Demorest, i.e., dissolving the alloy in concentrated  $H_2SO_4$  and titrating with potassium permanganate and iodine for antimony and tin is inadequate for the many alloys containing considerable copper.

First, 5 per cent or more of copper severely affects the tin titration, and second, with copper over 75 per cent, as is the case in many alloys and scrap metal, the alloy is dissolved in sulphuric acid with difficulty, if at all.

For these reasons the following modification of that method is presented:

**Method:**—Place 1 gram of the drillings in a No. 3 beaker and add 50 c.c. of 1.20  $HNO_3$ . After dissolving in the cold for a few minutes, place on hot plate and evaporate to about 10 c.c. Now dilute with water and boil a minute or so. After settling decant through a fine filter paper, leaving as much of the precipitate as possible in the beaker. Again boil the precipitate with  $HNO_3$ , dilute, filter all the precipitate off on the paper and wash well with hot water.

The filter paper containing all the antimonie and meta-stannic acids is put without drying into a beaker and 40 c.c. of  $H_2SO_4$  (specific gravity 1.84) poured upon it. The filter paper is immediately blackened and partly dissolved. Now add a small quantity of water (about 15 c.c.) and place on the burner, watching that it doesn't boil over. (The addition of water at this point is done to prevent explosions when the  $KClO_3$  is added.) Now add  $KClO_3$ . By repeated additions to the hot solution the carbon is completely burned out, leaving a colorless solution. If any precipitate still remains, a few minutes' vigorous boiling will dissolve it.

To the clear solution add about  $\frac{1}{2}$  gram of sulphur and boil one-half hour. Most of the sulphur will have disappeared at the end of that time, leaving the antimony in the "ous" condition and the tin in the "ic" condition. Cool, remove the ball of sulphur and dilute with three times its volume with water. Any lead that was carried down with the antimony and tin during the original treatment with  $HNO_3$  will occur as  $PbSO_4$  at this point and should be filtered on a gooch and weighed. (This usually happens with high tin and antimony alloys.)

The solution from the  $PbSO_4$  filtration is heated to 60 deg. C. and standard permanganate run in to a deep pink color. Stir well and titrate back to colorless with standard ferrous sulphate. The iron factor of the permanganate times 1.076 gives the theoretical factor for antimony. It is always well to standardize the permanganate against C. P. antimony. The permanganate solution should be about 1/15 normal.

**Tin.**—After titrating, pour the solution into a large Erlenmeyer flask, add one-third of the solution's volume of strong  $HCl$  (1.20) and place on hot plate. If the alloy does not contain 15 per cent or more of antimony add enough of a solution of  $Sb_2(SO_4)_3$  to bring it up to that percentage. Heat to boiling and add short lengths of soft iron wire from time to time so as to evolve a rapid continuous stream of hydrogen. A stopper should be loosely fitted to exclude the air and so insure a complete reduction of the tin. Reduce in this manner three-quarters of an hour and then take off hot plate, cooling

to tap water temperature with the stopper still in the flask.

When cool filter off the iron wire and precipitated antimony by means of suction through asbestos into a suction flask. Titrate immediately with 1/10 normal iodine to a blue color with starch. One c.c. of a 1/10 normal solution of  $I=0.00595$  tin. This iodine solution is standardized against C.P. tin, reduced as above after dissolving the metal in concentrated  $H_2SO_4$  (1.84).

**Lead.**—While titrating the antimony and tin, have evaporation of the nitric acid solution of lead, copper, etc., progressing after addition of 15 c.c. of concentrated  $H_2SO_4$ . When down to fumes cool and add twice its volume of water and filter off the  $PbSO_4$  on a weighed gooch. Wash well and heat to dull redness for a minute or so over a Bunsen flame. This may be done to the best advantage by placing the gooch inside of a larger porcelain crucible. Weigh and  $PbSO_4$  times 0.683 gives the percentage of lead. Any lead recovered from previous operations is added, giving total lead.

**Copper.**—Pass  $H_2S$  through the filtrate from the  $PbSO_4$  determination, precipitating the copper as sulphide.

(A) If the alloy is of high copper content (around 75 per cent) dissolve the  $CuS$  in nitric acid, take down to sulphuric acid fumes and after diluting add ammonia to the neutral point and then 4 c.c. of  $HNO_3$  (1.42). Electrolyze at three volts and 0.3 to 0.5 ampere, using revolving cathode, if possible.

(B) If, however, the copper content is low (around 10 per cent), some of the copper will have been lost previously in the analysis by being occluded with the tin and antimony precipitates and not recovered. A separate analysis is now necessary.

Dissolve 1 gram of the alloy in 40 c.c. of concentrated  $H_2SO_4$  (1.84), boil a minute and cool. Dilute with twice its volume with water, let settle, and filter of  $PbSO_4$  on a weighed gooch. Heat the filtrate to 60 deg. C. and titrate for antimony with permanganate and ferrous sulphate as described above. Checks may thus be obtained on both lead and antimony if desired.

To the solution now add 3 grams of tartaric acid, make slightly alkaline with ammonia, and add 3 c.c. of concentrated  $H_2SO_4$ . The tartaric acid holds the antimony in solution. (The solution at this point must have considerable volume to prevent the precipitation of ammonium salts.) Heat to boiling, add 2 grams of  $Na_2S_2O_3$  and when dissolved add a solution containing about 1 gram of  $KCNS$ . Keep hot for fifteen minutes and then filter on a weighed gooch, wash well with hot water, dry at 110 deg. C. and weigh as  $CuCNS$  containing 0.5226 per cent of copper.

**Iron.**—This element occurs sometimes in scrap and should be determined at this point by precipitation with ammonia and either titrated or weighed as the oxide.

**Zinc.**—Boil off the  $H_2S$  from the copper sulphide filtrate and after confirming the presence or absence of iron, treat the solution so as to make it slightly acid. Heat and add 3 to 5 grams of sodium acetate and then an excess of a solution of  $NaNH_2HPO_4 \cdot 4H_2O$  and let settle. Filter the precipitated zinc ammonium phosphate on a weighed gooch, and after heating well over a Bunsen burner weigh as zinc pyrophosphate containing 42.9 per cent zinc.

METHOD FOR BEARING METALS CONTAINING ONLY  $Sn$ ,  $Sb$  AND  $Pb$  (DEMAREST)

Dissolve 1 gram of filings or chips in 40 c.c. of  $H_2SO_4$



(1.84) and determine Pb and Sb as described under Copper (B). To determine the tin, take solution from the antimony titration and after reducing as described under the tin determination titrate with iodine.

**Notes.**—In spite of many authors' precautions against the oxidation of the reduced tin, no trouble has been experienced in this method.  $\text{CO}_2$  has been found to be unnecessary. To make the  $\text{Sb}_2(\text{SO}_4)_3$  solution used in the tin titration, dissolve 1 gram of C. P. antimony in 75 c.c. of boiling  $\text{H}_2\text{SO}_4$  (1.84) and after cooling add 25 c.c. of water. 1 c.c. of this solution equals 0.01 gram of antimony.

The occlusion of copper in high tin and antimony and low copper alloys makes the above separate determination for copper necessary. The lead carried down is later recovered.

The large amount of  $\text{KClO}_3$  necessary to oxidize the filter paper does no harm and serves to prevent the volatilization of the tin and antimony as their chlorides.

CARLTON G. LUTTS.

LYNN, MASS.

### Bottle Filling Alarm

To the Editor of Metallurgical & Chemical Engineering:

SIR:—Keeping in mind water bottles while being filled from a still is positively a nuisance, and most people who have this duty to perform succeed in occasionally allowing them to overflow. To obviate this annoyance the alarms shown in the adjoining sketches were

rise till contact is made, closing circuit. The contacts by this method are very satisfactory, but the mercury is apt to spill and the volume of air in tube varies with the temperature, causing alarm to ring with water at different levels under varying conditions.

To obviate these difficulties devices illustrated by Figs. 2 and 3, which are self-explanatory, were tried. The floats were made from  $\frac{1}{2} \times 4$ -in. thin wall test tubes, weighted with mercury. In Fig. 2 the float is capped with a cartridge shell surfaced with silver foil. The wire contacts are of platinum soldered to copper leads with silver solder and fused into glass tube. The curved contact wire in Fig. 3 was rolled out thin to give it necessary flexibility.

These alarms have been in use for about three years, giving entire satisfaction.

E. J. HALL.

School of Mines, Columbia University, New York City.

### Carbon Determination by the Combustion Method

To the Editor of Metallurgical & Chemical Engineering:

SIR:—The opening sentence of a communication under the above caption, in the February number furnishes an alluring text for a dissertation, but why go to the trouble—and incur expense and perhaps danger—in correcting a condition which need not or should not exist?

The simple expedient of lining the boat with powdered alundum, prevents the fused metallic residue sticking to the boat.

Boats may be made of any one of a number of different materials, but the writer recommends nickel of 22 gauge—B. & S. Blanks are cut from the sheet and stamped on a steel die; rough edges are then trimmed off and filed smooth. The boats cost a trifle under five cents each and average not less than 40 combustions.

The alundum is 60 mesh and lasts indefinitely except for such mechanical loss as is sustained in removing the fused residue. The residue is simply lifted from the bed of alundum and the boat is ready for the next combustion.

Both boat and alundum are ignited until free from carbon, before being used. The operator has his choice of a number of different materials for lining the boat but alundum is recommended.

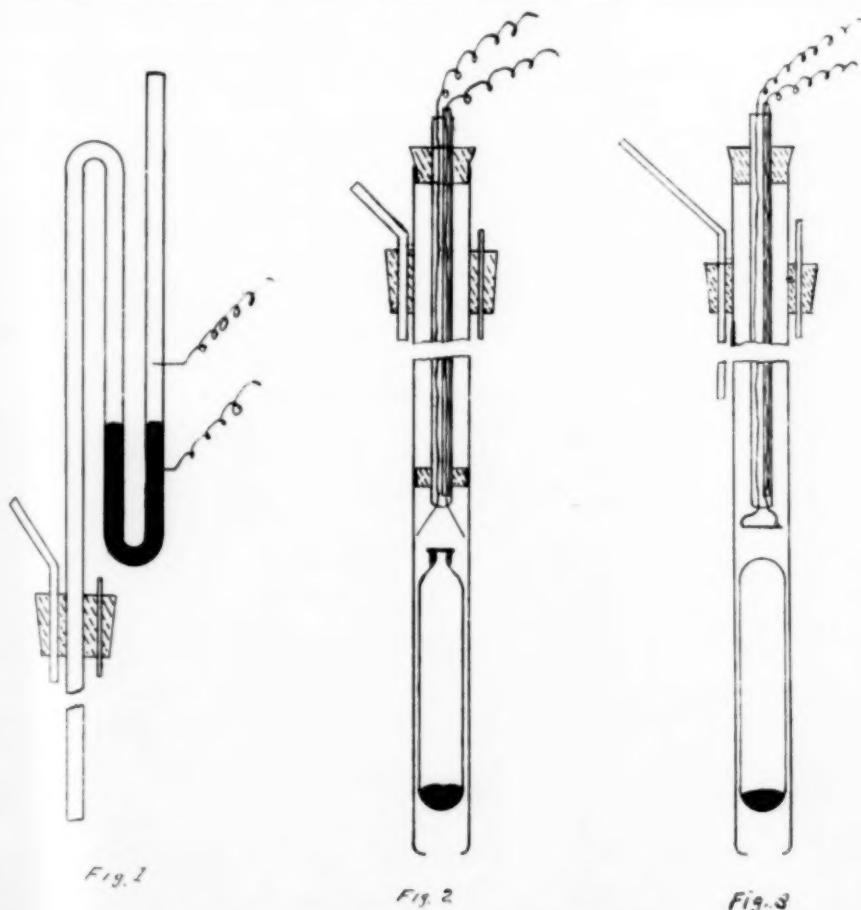
This practice is not detailed as embodying anything new, but judging from the article above referred to, it may be new to some.

C. H. RICH.

Alan Wood Iron & Steel Co.,  
Conshohocken, Pa.

**Lead Poisoning in Manufacture of Storage Batteries** is the subject of Bulletin 16S of the Bureau of Labor Statistics of the Department of Labor. The author is Dr. Alice Hamilton. It is thought that the dangers of the industry

can be reduced to a minimum by installing hoods and exhausts to carry off fumes and dusts by substituting machine for hood work, by providing ample washing facilities for the workmen and insisting on strict cleanliness everywhere and by providing a separate lunch room as the only place where food may be kept and eaten.



FIGS. 1 TO 3—BOTTLE FILLING ALARM DEVICES

constructed. The leads are connected in series with a battery and bell.

In Fig. 1 the center tube passing through cork reaches almost to bottom of water bottle. The angle tube is inlet and short vertical tube acts as a vent. As bottle fills pressure is produced, causing mercury to



## The Western Metallurgical Field

### The Porphyry Coppers in 1914

Among the annual reports issued by mining and metallurgical companies of the United States, none excel those of the great "porphyry" copper companies of the West. In addition to giving the fullest publicity to company affairs in a financial and commercial way, these companies include in their reports many interesting and valuable data on engineering operations, their cost and result. Several of them being under the control of the same group of men, their reports are uniform in arrangement and nature of data presented, thus facilitating easy comparison of the operations at different points. In the accompanying table we give the salient facts regarding the operations of the Utah, Ray Consolidated, Nevada Consolidated, Chino and Miami copper companies for 1914.

All of the companies mentioned operated at reduced capacity during the last five months of the year. The Utah company closed its Arthur plant entirely on August 6, 1914, but continued operations in the Magna plant. The latter handled an average of 12,223 tons daily throughout the year, and the former an average

of 9214 tons daily for the period of operation. Recoveries were affected adversely by the presence of considerable quantities of oxidized copper minerals in the ores mined near the surface, but this condition will disappear as further progress in stripping is made. In spite of curtailed operations, however, the cost of production for the last five months of the year was 0.509 cents less per pound of copper than for the first seven months. This improvement was due partly to improvements in operation and partly to better grade of ore treated.

	Utah	Ray Consolidated	Nevada Consolidated	Chino	Miami
Ore reserves, tons	342,500,000	74,765,789	41,020,296	90,270,155	36,500,000
Average content copper, per cent.	1.45	2.214	1.75	1.75	1.85
Ore treated, tons	6,470,166	2,427,700	2,640,294	1,907,300	1,096,633
Average content copper, per cent.	1.425	1.76	1.48	2.12	2.28
Gross copper production, lb.	121,779,401	59,044,700	49,244,056	56,841,977	35,048,445
Average recovery, per cent.	66.04	67.88	68.48	67.86	69.93
Average copper in concentrate, per cent.	18.19	19.25	66.15	18.50	39.31
Average cost milling, cents per ton	35.36	49.88	.....	55.91	49.96
Cost of copper, cents per lb. <sup>1</sup>	8.131	8.839	10.16	7.68	6.46
	7.245	8.763	9.82	7.35	.....
Gold production, oz.	34,729	.....	16,946	.....	.....
Silver production, oz.	325,351	.....	49,631	.....	.....

<sup>1</sup>First figure based on net production after making smelter deductions and applying credit for gold and silver. In second figure credit is applied for all miscellaneous income.

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At Ray the percentage extraction was increased, due to improved methods of operations, and cost of milling also was reduced. During the latter part of the year investigations were completed which will immediately insure lower cost of operation, higher grade of concentrate, increase in recovery and saving in smelting charges.

Nevada Consolidated completed the acquisition of the property of the Steptoe Valley Smelting & Mining Company, the latter company having been dissolved on Nov. 28, 1914. All operations of milling, mining and smelting are now conducted by the Nevada Consolidated company. Improvements at the mill consisted in adding Dorr thickeners and a new set of rolls. In the reverberatory smelting department there was a reduction in costs and fuel ratio. The capacity per furnace was increased from 481 tons per day in 1913 to 598 tons in 1914.

Chino installed an improved plant for enrichment of concentrates, thereby increasing the amount of gold in concentrates sufficiently to be credited under the smelting contract. The gold credit amounts to 2.71 cents per ton of crude ore treated, or 0.1 cent per pound of copper produced.

Miami completed changes in the mill, based on pre-

vious experiments, that will result in increased capacity and efficiency. The change consists mainly in finer grinding and additional table capacity on the sand floor, and improved methods of treating slime. The changes in treatment will result in a metallurgical efficiency as high as is possible with the present state of the art.

### Flotation at Silverton, Colorado

The American Ore Flotation Company is a newly organized concern which contemplates the application of the flotation process in the San Juan district of Colorado. The company has leased the Silver Lake mill, near Silverton; has purchased the Ben Butler mining property at Mineral Point, above Animas Forks, and has taken options on the Mayflower in Arastra Gulch, and the Champion below Silverton. The mill is being equipped for flotation treatment, but will not be ready for operation until mid-summer. The promotion and operations of the company are reported to be in the hands of E. W. Weybright and D. L. Thomas, respectively, the latter having been previously an employee in the mill of the Butte & Superior Copper Company, where James M. Hyde installed and operated the first successful flotation plant in this country. Contrary to

rumor, Mr. Hyde is in no way connected with the company at Silverton. The introduction of flotation in Colorado mills promises to be a large factor in increasing recovery and profits from low-grade mixed sulphide ores, particularly in improving former practice in slime concentration.

### Marked Activity in the Joplin District

The continued strength of the zinc market is being reflected in unusual activity in the zinc-mining and milling districts of Missouri and Kansas. According to the *Joplin News-Herald*, the Joplin district produced 82,000 tons of zinc blende concentrates during the first four months of 1915. In view of the large number of mills being built or placed in operation, it is likely that the present rate of production is even higher. Profits for the first four months were not as large as can be anticipated at the present time. During the week ended May 9, deliveries of zinc concentrates were made on a basis of \$75 a ton, 60 per cent metallic zinc. This price was previously reached in February for choice grades of ore, but the demand for second grades at that time was not good. The price of \$75 represents an advance of \$10 within two weeks, and the market is reported firmer than ever before in the history of the Joplin district.

New mills are being constructed and old ones rehabilitated. The Moreland custom mill has begun operations with a capacity of 150 tons per day. The mill of the Century company has been completed and is expected to be in operation shortly. Work has been resumed on the C. & S. No. 4 property after an idleness of fifteen months. The mill has a capacity of 250 tons a day. A new custom mill has been constructed in the Galena district, and nine concentrating plants are reported to have resumed operations at Aurora. A contract has been let

for the construction of a new 400-ton tailing mill for the Rollamo company north of Webb City. Near Stotts City a new 250-ton mill is being built on the Hill land. In the Lawton, Kan., district Greenfield & Lockwood have let a contract for the construction of a modern 300-ton plant.

#### Resumption of Copper Production in the West

It is reported that the Utah, Chino, Ray Consolidated and Nevada Consolidated copper companies are again operating at about full capacity. The improvement in the copper market and increased demand for the metal lead those conversant with conditions to believe that the increased production is warranted and that there is little or no danger of overproduction. The policy adopted by the companies last August, of retaining their working forces by offering employment at half time, has enabled them to increase production in a short period of time. The flexibility of their operations will enable these companies to curtail the output should the necessity appear.

#### Cyaniding at Cobalt

Prior to the outbreak of the European war many of the companies operating concentrating mills at Cobalt, Ontario, Canada, were either experimenting with the cyanidation of slime or had made definite plans for the addition of a cyanide plant to the existing mills. Among these the Cobalt Reduction Company had made many experiments which indicated the successful use of cyanidation. The plant has been constructed and was placed in operation about May 1. It will treat about 175 tons of slime per day, cyaniding that part of the pulp which formerly was treated by slime concentration, and producing bullion instead of slime concentrate. In addition to treating current slime from its own plant, the company will handle also the slime from the Cobalt Lake concentrator which will be delivered by a pipe line 1200 ft. long.

#### Company Reports

In the annual report of the Inspiration Consolidated Copper Company for the year 1914, General Manager C. E. Mills gives the following information under date of March 17, 1915. Copper production will begin during the month of June, the delay in the anticipated date being due to the change in milling plans and the adoption of flotation. The resultant combination flow-sheet involving the use of both ordinary water concentration and oil flotation will show an increase in copper recovery as compared with the use of either of the processes alone. Flotation testing was conducted during the entire year 1914, and at the same time experiments were made on grinding machinery. Parallel tests were run on various flow-sheets and five different flotation machines. The scheme finally adopted is, in brief, as follows: Crushing to 4-in. maximum size in gyratories, and further reducing to 1½ in. in Symons disk crushers. This work will be done at the mine. At the mill the ore will be ground to pass forty-eight-mesh by means of Marcy ball mills. The product will be treated in flotation machines. The tailings from flotation will be separated into sand and slime, the former being treated on concentration tables and the latter retreated in flotation machines. The concentrates will be dewatered in a filter plant.

The experimental plant showed a recovery during the month of February of 90.3 per cent of the copper occurring in sulphide form. The saving of oxidized forms of copper is not fully determined, but probably ranges from 20 per cent to 30 per cent. The average quantity of copper in oxide form in the ore milled last year was 0.16 per cent out of a total of 1.52 per cent copper. In

such ore a recovery of sulphides of 86.7 per cent would correspond to a recovery of total copper of about 80 per cent. During 1914 the mill treated 172,722 tons of ore averaging 1.52 per cent copper. Inspiration concentrates will probably contain from 28 per cent to 32 per cent copper, and contain sufficient sulphur to make a suitable grade of matte in smelting. The mill will consist of eighteen sections, each of 800 tons daily capacity. The first nine sections are expected to be completed simultaneously, and the others before the end of this year. The transfer of the property of the New Keystone company to the Inspiration has been effected. Total ore reserves of Inspiration are estimated as follows:

	Tons	Per cent copper
Sulphide ore .....	46,252,000	2.01
Low sulphide material .....	28,698,000	1.26
Oxidized material .....	17,460,300	1.31
Mixed carbonate and sulphide .....	4,732,700	1.31
Total and average .....	97,143,000	1.63

#### The Iron and Steel Market

Developments during May in the steel market proved unexpectedly favorable. As noted in our review a month ago the future of the steel market hung in the balance. The improvement that had occurred during three or four months preceding had not continued through April and unless fresh favorable developments occurred conditions were likely to become distinctly less favorable. When the steel market is bad it may remain continuously bad and when it is good it may be continuously good for some time, but at a midway point it never halts; it must always be swinging towards the one extreme or the other.

The favorable developments in May were distinctly along two lines, export demand and railroad demand. Accurate details of export buying are largely lacking, partly because the orders are largely for war purposes, but it is known that many orders have been placed, others being still in the market, for 10,000-ton and larger lots of steel, chiefly in the form of merchant rounds for rifles and for shrapnel. Apart from war munitions, there has been Russian buying of both freight cars and rails, 9000 cars being placed in the United States and 6000 in Canada, with 7000 still to be placed. Rails purchased by Russia already exceed 50,000 tons, and statements of the total tonnage to be bought range from 100,000 to 500,000 tons.

Apart from 2500 freight cars placed at its Altoona shops the Pennsylvania railroad system has bought 14,000 cars and is understood to have arranged for 138,000 tons of rails and about 200 locomotives and about 200 passenger cars, some of the locomotives to be built in its own shops. The total tonnage involved in all these purchases is not far from 550,000 gross tons.

There has been tentative inquiry in the market for 15,000 or more cars for other roads, and a few locomotives. It is expected that the liberal buying policy adopted by the Pennsylvania will cause other roads to purchase more freely.

March exports of iron and steel totaled 175,000 gross tons, for commodities returned by weight, and with steel involved in machinery and other manufactures exported the exports may have represented 10 per cent of the steel industry's capacity. The export movement has undoubtedly increased since March and June exports may easily represent 15 per cent of capacity. In the early months of the year railroad material shipped probably did not exceed 5 per cent of capacity, but there are distinct possibilities that within a month or two railroad material may involve 15 per cent of the capacity. With such increases the recent operating rate of



70 per cent of capacity may mount to well above 80 per cent, or to a point at which the supply of labor may prove to be an important element. It is doubted whether the steel industry could find sufficient labor to operate at capacity on short notice, seeing that increases in steel demand are naturally attended by more employment outside the steel manufacturing industry.

Fabricated steel contracts let in April are reported at 107,500 net tons, against 110,000 tons in March. The monthly average in the seven months preceding was but a trifle above 50,000 tons, so that the March and April showings, while low compared with normal times, represent a great improvement.

#### Pig Iron

The consumption of merchant pig iron has been increasing, but very slowly. There is somewhat freer buying, but scarcely in larger lots, for given periods, than formerly. A few idle merchant furnaces have been blown in, but the total increase in production is small. It is the general opinion that few more idle stacks will be gotten into blast unless materially higher prices are offered for iron. Pig iron prices have been phenomenally steady for a long time, at low levels, but in some quarters there is an expectation that a phenomenal advance may occur within a few months to break the monotony. In the past five months the average price of all descriptions of pig iron has not varied by 25 cents a ton, but conditions are perhaps such as to encourage a very sharp advance, once one is started. Southern iron is definitely higher than a month ago, by fully 25 cents a ton. We quote No. 2 foundry, delivered Philadelphia, \$14.25 to \$14.50; f.o.b. furnace, Buffalo, \$13; delivered Cleveland, \$13.25; f.o.b. furnace, Chicago, \$13; f.o.b. Birmingham, prompt, \$9.50; third and fourth quarters, \$9.75 to \$10; at valley furnaces, 95c higher delivered Pittsburgh; Bessemer, \$13.60 to \$13.75; basic, \$12.50 to \$12.65; No. 2 foundry, \$12.75 to \$13; gray forge, \$12.50 to \$12.75; malleable, \$12.75.

#### Steel

Fresh market transactions are very limited, consumers being covered by contracts on which occasional private adjustments are made. Prices are largely nominal at \$18.50 to \$19 for billets and \$19 to \$19.50 for sheet bars, at maker's mill, Youngstown, and at about 50 cents higher at maker's mill, Pittsburgh, with forward deliveries commanding somewhat higher prices. Rods are firm at \$25, Pittsburgh.

#### Finished Steel

Demand for merchant bars has been excellent, as reinforced by the requirements for war purposes, and prices are strictly maintained. Plates continue weak. Galvanized sheets were advanced by the American Sheet & Tin Plate Company on May 17 from 3.40 cents to 3.60 cents, but only limited tonnages were sold at the new price, and the extreme scarcity of spelter makes it probable that further advances will occur, if indeed galvanized sheets do not disappear entirely from the market. The decrease in galvanized sheet production has caused more active competition for black sheet orders, and the black sheet market is weaker if not actually lower. On May 1 the National Tube Company advanced steel pipe, boiler tubes and line pipe by one point or about \$2 a ton, other makers as a rule following the advance.

Current quotations are as follows for ordinary deliveries and are f.o.b. Pittsburgh unless otherwise noted: Rails, standard sections, 1.25c for Bessemer, 1.34c for open-hearth, f.o.b. mill except Colorado.

Plates, tank quality, 1.15c. to 1.20c.

Shapes, 1.20c. to 1.25c.

Steel bars and bands, 1.20c to 1.25c., base; hoops, 1.25c. to 1.30c., base.

Iron bars, 1.20c. to 1.25c., Pittsburgh; 1.17½c. to 1.22½c., Philadelphia; 1.15c. to 1.20c., Chicago.

Sheets, blue annealed, 10-gage, 1.35c.; black, 28-gage, 1.80c.; galvanized, 28-gage, 3.60c.; painted corrugated, 28-gage, 2.00c.; galvanized corrugated, 3.65c.

Tin plate, \$3.10 to \$3.20 for 100-lb. coke.

Steel pipe, 79 per cent off list.

Steel boiler tubes (less than carloads), 3½-in. to 4½-in., 74 per cent off list.

### The Non-Ferrous Metal Market

During the month that has elapsed since our last report the market for lead has remained about stationary, while tin has receded. Spelter, on the other hand, has had a remarkable rise, and copper also has advanced. The demand for all metals continues strong and the prospect seems good for continued high prices.

**Copper.**—Early in May the price of electrolytic advanced to 18.30 @ 18.80 cents, New York, but quieted later to about 18.50 @ 18.60. Some sellers continued to ask up to 19 cents, but did little or no business in competitive markets. The demand for copper continues good and some very large orders are pending.

**Tin.**—This market has declined steadily during the month, and is generally quiet. May tin is quoted at about 40 cents, New York.

**Lead.**—Business continues fair, with apparently ample supply to meet the demand. Inquiry for military purposes lends interest to the market. New York lead is quoted at 4.20 @ 4.25 cents, with St. Louis at 4.12½ @ 4.15 cents.

**Spelter.**—After receding somewhat from its previous high level of prices, this market experienced a remarkable rise in the face of a comparatively light domestic demand. Smelters are being operated to capacity but have no stocks and are unable to produce enough for immediate needs. The latest quotation is 12½ @ 13½ cents, St. Louis.

**Other Metals.**—Aluminium is in greater demand and the New York quotation is firm at 19½ @ 19¾ cents for No. 1 ingots. Prices for antimony have risen again in the face of decreasing supply. Ordinary brands are quoted at 35 @ 37 cents, with special brands at 40 @ 45 cents. Quicksilver is somewhat higher, bringing \$74 per flask of 75 lb., New York.

### Paint Remover Patent Decision Before Court of Appeals

The decision of the United States District Court, Southern District of New York, in the suit of the Chadeloid Chemical Co. against the Wilson Remover Co. and J. McN. Wilson, in favor of the complainant and upholding the Carleton Ellis patent 714,880 of December 21, 1902, has been upheld by the United States Circuit Court of Appeals (Judges Coxe, Ward and Rogers).

From the decision of the Court of Appeals, written by Judge Coxe, we quote the following:

" . . . Neither do we think that the testimony of learned experts and chemists, who have made many experiments to prove that the paint remover of the patent which does the work and satisfies the trade, is old and inefficient, can be relied on in the face of proof showing its widespread popularity and satisfactory results. Ellis was the first to produce such a remover. It is the hunter who actually brings down the game who is entitled to carry it home. The need

<sup>1</sup>See METALLURGICAL & CHEMICAL ENGINEERING, February, 1915, p. 129.



of an efficient and harmless paint remover had been felt for many years by the trade. Efforts to supply it were many but unsuccessful. Caustic alkali removers were tried and failed; they got rid of the paint but injured the wood. Carbolic-fusel oil removers were tried, but the carbolic acid proved dangerous to the workmen and injured the new paint when applied to the wood. All of these matters were considered in the litigation in the District Court and they were held not to negative the invention of the non-corrosive harmless removers of the Ellis patent.

"The Bennet and Arnstein removers were considered in the original case but were held not to defeat the invention of the Ellis patent and to belong to the same class as the other prior carbolic-fusel oil removers, where wax and similar substances were used as thickeners, and were not mentioned to retard evaporation. If the old removers were satisfactory and did the desired work why are they not used today? How can we account for this persistent effort, during ten years of litigation, to use the Ellis product, upon any other theory than that the prior removers were wholly insufficient? The necessity for a practical remover was felt and many experiments were tried, but no practical result was reached until the Ellis composition was produced.

"The testimony in support of this proposition is clear and persuasive; it is not necessary to review it in detail further than to say that it comes from manufacturers and large dealers and is to the effect that the carbolic acid-fusel oil removers were ineffective, dangerous to health, destructive to the wood, offensive in use and lamentable failures generally.

"The Ellis composition solved a problem which prior to 1902 had baffled the efforts of those who realized the dangers and shortcomings of the existing removers but seemed incapable of remedying them. The solution was not the result of a mere guess but was due to persistent effort by Ellis, who is an educated chemist of standing and reputation, who studied the problem with care and reached a solution which has solved the problem successfully. This is done without injuring the wood operated upon or endangering the health of the workmen. No one before had achieved this result.

"We see no ground for criticism of the patent *per se*. In fact we think the patentee and the officials of the Patent Office are to be commended for having issued a chemical patent where the description and claims cover less than a page. The patent is clear, concise and intelligible to laymen. The criticisms are not well founded. It was not necessary or wise to specify the exact proportion of wax, as this differs according to the work being done. Had the exact percentage been named, anyone could evade the patent by using more or less than the specified amount and thus could have secured all the advantages of the invention without the payment of a dollar."

### International Engineering Congress

The International Engineering Congress will be held in San Francisco from September 20 to 25, 1915, under the auspices of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Institute of Mechanical Engineers, the American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers.

The membership fee is \$5, and should be remitted to W. A. Cattell, treasurer, Foxcroft Building, San Francisco, Cal.

This membership fee entitles the member to

(a) Full participation in the Congress.

(b) A volume reporting the general proceedings of the Congress and containing indexes and digest of other volumes.

(c) Any single volume of the Transactions which the member may select.

There will be ten volumes, as follows: Vol. 1, The Panama Canal; Vol. 2, Waterways and Irrigation; Vol. 3, Municipal Engineering; Vol. 4, Railways and Railway Engineering; Vol. 5, Materials of Engineering Construction; Vol. 6, Mechanical Engineering; Vol. 7, Electrical and Mechanical Engineering; Vol. 8, Mining and Metallurgy; Vol. 9, Naval Architecture and Marine Engineering; Vol. 10, Military Engineering.

### Pacific Coast Meetings of National Chemical Societies

All the three national chemical societies of this country will hold their autumn meetings in the West.

The start will be made by the American Institute of Chemical Engineers, which will hold a meeting in Los Angeles, Cal., on the evening of Wednesday, August 18th (jointly with the Southern California Section of the American Chemical Society), and a four day meeting at San Francisco from August 25th to 28th (Wednesday to Saturday).

The next in time will be the American Chemical Society, which will hold its meeting in Seattle, Wash., from August 31st to September 3rd (Tuesday to Friday). On September 2 the party of the American Institute of Chemical Engineers will be in Seattle and attend the meeting of the American Chemical Society.

The American Electrochemical Society will hold its meeting in San Francisco on September 16th, 17th, 18th (Thursday to Saturday) simultaneously with meetings of the American Institute of Mining Engineers and the American Institute of Electrical Engineers. Joint sessions are planned. On Monday of the following week (September 20) the International Engineering Congress starts.

### Exposition of Chemical Industries

A national exposition of chemical industries is proposed to be held in the New Grand Central Palace, Forty-sixth Street and Lexington Avenue, New York City, during the week of September 20 to 25, 1915.

While expositions of chemical industries have been held before in Europe, this will be the first chemical exhibition to be held in the United States.

The time for holding the exposition is undoubtedly well chosen. The psychological moment has come to place the achievements of industrial chemistry visibly before a wider and vitally interested public and to bring the manufacturers of machinery and apparatus for the chemical industries in such close contact with industrial chemists as the facilities of an exposition afford. If properly managed such an exposition must be of great benefit to the industry.

An advisory committee has been formed consisting of Messrs. Raymond F. Bacon, Charles H. Herty, A. D. Little, R. P. Perry, Wm. Cooper Procter, E. F. Roeber, George D. Rosengarten, T. B. Wagner and Utley Wedge.

The exposition is being organized and will be managed by Messrs. Charles F. Roth and Adriaan Nagelvoort, with offices at the New Grand Central Palace, Forty-sixth Street and Lexington Avenue, New York City (telephone Murray Hill 6990). Associated with them in the management is the International Exposition Company, which has successfully managed the Automobile Show, the Horticultural Show and others.

## Beta Iron

"Satire Allotropique," presented at the dinner of the Iron and Steel Committee of the American Institute of Mining Engineers.

BY ALBERT SAUVEUR

Fer bêta, conception du grand allotropiste,  
Contre toi, profitant de la sortie du maître,  
Se rangent tes rivaux faciles à reconnaître,  
Mirmidons entraînés par propos carbonistes.

Hadfield l'avait bien dit: le carbon seul durci.  
Alpha, bêta, gamma, composants inutiles,  
Ne pouvant arrêter le moindre projectile,  
Doivent être relégués, et cela sans merci.

Arnold, chacun le sait, toujours a préféré,  
Par lui seul découvert, un carbure éphémère,  
Une formule étrange, véritable chimère,  
Création fabuleuse qui ne peut qu'égarer.

Quant à Henry M. Howe, de nous tous le mentor,  
Avec une justice qu'on rarement rencontre,  
Il pèse sans faveurs les pous et les contres,  
Et nous dira bientôt qui a raison ou tort.

Stead est décourageant par sa neutralité.  
Tschernoff et Belaiew, fidèles amis slaves,  
Des nouveautés anglaises ne seront pas esclaves,  
Ce qui prouve après tout pour leur mentalité.

Guillet, Grenet, Charpy, Henri Le Chatelier  
(Pour Frémont ces questions ont trop de théorique,  
Son fort étant plutôt celui de la pratique)  
Ne sont pas de bêta des ardents chevaliers.

Rosenhain avec lui semble jouer cache-cache:  
Il l'attrape, il le tient, proclame qu'il est dur.  
On accourt, on regarde, cette fois on est sûr,  
Mais hélas aussitôt, voila qu'il le relâche.

C'est un slip band dit l'un, un simple glissement.  
Du ciment dit un autre, un rien allotropique,  
Pas même un métastable, un point mathématique,  
Un décristallisé à chasser vite.

Benedicks dans gamma le veut ensevelir,  
McCance l'écrourir, Edwards en faire des mâcles:  
Le malheureux bêta devant cette débâcle,  
Se soumet à son sort, se résigne à mourir.

Il attend son destin, triste et mélancolique,  
Abandonné de tous, même de martensite,  
Qui prétend n'être plus que rides d'austénite.  
Il deviendra amorphe. Adieu son point critique.

Pour comble de malheur, et sans le consulter,  
Un docteur Suédois le veut mettre sous terre,  
Assisté dans sa tâche, par Monsieur Carpenter,  
Car, dit il, il est mort, on le peut constater.

Etant de phlogistique tellement dépourvu,  
Qu'on ne sait en tirer le moindre point thermique,  
Ni dans sa courbe voir la plus petite crique.  
Tel manque de chaleur s'est très rarement vu.

Le verdict est rendu, le sort en est jeté:  
D'un certain diagramme if faudra qu'on efface,  
(Car on doit obéir à la règle des phases)  
Ce déséquilibré, enfantement raté.

Quand vous aurez, Messieurs, fini vos beaux discours,  
Et que l'heure viendra, pour gagner votre pain,  
De durcir vos aciers et d'assurer vos gains,  
Il faudra que bêta vienne à votre secours.

## Obituary

**Franklin Guiterman**, director of the American Smelting & Refining Company, and manager of its Colorado department, died from pneumonia in New York City May 2. He was 59 years of age. Through his many years' experience in mining and smelting in the West, and his association with numerous companies for over 35 years, he was widely known as a competent metallurgist and business manager.

Mr. Guiterman was born in Cincinnati, O., where he received his early education. Later he attended Columbia University and finally graduated at the Bergakademie at Freiberg, Saxony, in 1877. Returning to the United States he became associated with some of his Freiberg classmates who were then engaged in the pioneer operations of mining and smelting in Colorado. Georgetown and Leadville, Colo., and Hartville, Wyo., were some of the scenes of his early work. Subsequently he went to Utah as superintendent of the Mingo plant of the Pennsylvania Lead Co. Returning to Denver in 1888 he entered the employ of W. J. Chamberlain & Co. as manager of the ore-buying business of that concern. In 1895 he was appointed manager of the Durango smelter in the San Juan district of Colorado. When the American Smelting & Refining Co. was formed he was made manager of its Pueblo plant and two years later he was made manager of the Colorado department of the same company, with headquarters at Denver. On March 1, 1912, he was transferred to New York, where he had charge of the research and technical investigations of the company and continued as manager for Colorado.

Mr. Guiterman was a prominent member of the Colorado Scientific Society, and as president of that organization for two years had much to do with its prosperity. He took an active interest in the affairs of national societies and belonged to the American Institute of Mining Engineers and the Mining & Metallurgical Society of America. In 1911 he was appointed a trustee of the Colorado School of Mines, but resigned when he removed to New York.

In 1886 Mr. Guiterman was married to Miss Mary B. Sproat, of Taunton, Mass. He is survived by his widow and one son, Kenneth S. Guiterman, chief chemist of the refinery of the Perth Amboy plant of the American Smelting & Refining Co.

**Rewards for methods of utilizing alcohol for industrial and technical purposes** have been offered by the Ministry of Finance, Russia, according to Consul General John H. Snodgrass, Moscow.

The premiums to be awarded are as follows:

(1) A premium of 100,000 rubles (\$51,150) will be awarded for the invention of a new method of utilizing alcohol for the manufacture of a product that will be essentially different from the alcohol used for its production. Examples of such products are vinegar, ether, chloroform, etc.

(2) A premium of 75,000 rubles (\$38,625) will be awarded for the invention of a new method of utilizing alcohol for the manufacture of a product in which alcohol and its derivatives (sulfuric ether and others) form the component parts of the product or the solvent, and from which it will be impossible to extract alcohol with a view to profit (as, for instance, pharmaceutical preparations).

(3) A premium of 50,000 rubles (\$25,750) will be awarded for the invention of a method in which alcohol and its derivatives would serve as a temporary intermediary solvent (as in the manufacture of smokeless powder and artificial silk).

(4) A premium of 25,000 rubles (\$12,875) will be awarded for the increase of the heating value of alcohol by the addition of substances that will make the use of alcohol as fuel advantageous.

(5) Three premiums of 5,000 rubles (\$2,575) each will be awarded for the invention or improvement of apparatus for the utilization of spirits in internal-combustion engines and for heating and illuminating purposes.

Inventions must be presented by January 1, 1916. They must be presented to the Chief Administration of Taxes and Sale of Drinks, written in French or Russian, in special envelopes bearing some motto. In another envelope, bearing the same motto, must be stated the name and address of the sender.

The papers must contain a detailed description of the conditions of the adaptation of alcohol, indicating the cost of the method when calculating the price of alcohol at 2 kopecks (1 cent) per degree on the alcoholometer.

Premiums will be awarded only such inventions or improvements as will involve a considerable consumption of alcohol.



## The Action of Certain Colloids on Ions During Electrolysis

BY A. MUTSCHELLER

Reports of investigations for the purpose of discovering suitable "addition agents" for electroplating and metal refining baths, are found to date back to as early as 1885 (M. Kiliani<sup>1</sup>). It had then already been recognized that the addition of certain substances to the bath had certain specific effects on the form and consistency of the deposit on the cathode. The nature of these investigations is purely qualitative, but more recently efforts have been made especially by Kern and his coworkers to find a theoretical explanation of the function of these "addition agents."

In reviewing the literature on this subject, especially the valuable articles of Kern,<sup>2</sup> certain analogies were found, as for instance, the general improvement of the deposit when the electrolyte is heated, or, that the quantity of an "addition agent" was found to be of importance, etc. These suggest that the additions must perform specific functions and that they do not act by their presence only. A selection from those substances which improve the deposit were recognized to be colloids and, as a rule, of the amphoteric or reversible type, hence colloidal phenomena were anticipated to be in play here. A further suggestion was found in the fact that the temperature coefficients on the rate of change of the migration velocity of the ions involved in the electrolysis are such that they tend

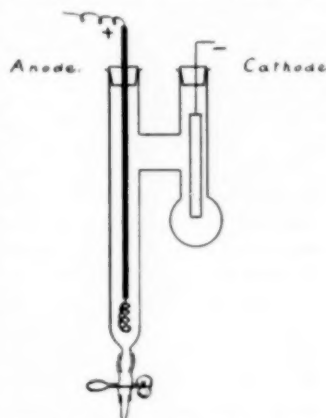


FIG. 1—HITTORF MIGRATION TUBE

to make the velocity of the two ions equal as the temperature rises. Moreover, the form of the deposit itself, such as it is obtained from a pure electrolyte in the form of striæ or branches was a sufficiently powerful inducement to a hypothesis that the regulation of the relative velocity of the ions should constitute the influencing factor in question. A few preliminary experiments substantiated this assumption and a more systematic continuation of these is herewith presented.

### EXPERIMENTAL PART ON SILVER NITRATE

The determination of the relative velocity of the ions was made in the customary manner by electrolyzing a salt solution in a so-called Hittorf's migration tube. This consists of an H-shaped tube about 1.5 cm in diameter of which one leg is about 15 cm long and closed by a rubber connection, a pinch cock and a glass tip. The other leg is short and closed at the bottom. The capacity of the tube is about 40 cc. (Fig. 1). For the determination, a foil of platinum about 6 cm<sup>2</sup> in area was placed in the shorter tube and made the cathode; in the longer leg was placed a glass tube through which a mercury connection was made and to the lower end of which was sealed a piece of the pure metal the migration velocity of whose ion was to be determined. This electrode was then connected with the positive pole of the electric current. The tube was filled near to the upper end with a solution which was prepared from c.p. chemicals and carefully distilled water. The current used was taken off along a resistance of about 36 ohms

after it had passed from 2 to 6 incandescent lamps. The time of run was ordinarily from 1 to 1½ hours; care being taken in every case to prevent disturbance of the apparatus during the experiment.

The first series of experiments on silver nitrate, the results of which are given in Table 1, were performed in the above described tube and the determinations were made as follows:

After the electrodes (the anode in this case consisting of pure silver) had been put in place and the solution poured into the tube the apparatus was allowed to stand in a shady place for about 15 minutes. After everything had come to rest the circuit was closed.

In the meantime 5 weighing flasks were prepared and 5 cc. of a 1/10 normal NaCl solution and 2 drops of K<sub>2</sub>CrO<sub>4</sub> solution were placed into each flask, after which the weight of each one was carefully determined.

After the run, the silver nitrate solution from the longer tube of the apparatus was run into the first weighing flask until the next drop produced a reddish precipitate or coloration. Then the other four flasks in turn were titrated in the same way, always employing care not to agitate the contents of the apparatus. After reweighing of each flask and deducing from the difference the known weight of AgNO<sub>3</sub> added (since the contents of the weighing flasks with respect to Cl<sup>-</sup> were of known titre, always the same weight of AgNO<sub>3</sub> was added to each flask), the remaining difference gave the weight of the water that contained the known amount of AgNO<sub>3</sub>.

An increase of concentration of silver nitrate was thus easily found, and as a rule, the third weighing flask (and, of course, the fourth and fifth) contained the same and constant amount of AgNO<sub>3</sub>.

The use of diaphragms, therefore, did not appear to be necessary so long as there was an increase of silver at the silver anode in the long leg of the tube. When the contrary was observed the arrangement of the electrodes was reversed so that it never happened that a solution of higher density was placed above one of lesser density. Vitiating of results due to diffusion seemed, therefore, satisfactorily prevented.

From the results obtained in this way the ionic migration velocities were calculated in accordance with the principle developed by Hittorf.<sup>3</sup> Calling  $c$  the amount of silver deposited on the cathode,  $r$  the amount of NO<sub>3</sub> (all expressed as AgNO<sub>3</sub>) and  $n$  the migration velocity of the anions we have

$$c:r::1:n$$

and  $1-n$  as the migration velocity of the cations.

In this series of experiments the concentration of the electrolyte consisting of a normal solution of silver nitrate was kept constant for all determinations, except that for each run a varying addition of a 1 per cent solution of gelatine was made. The results of these additions on the migration velocities of the ions are given in Table 1 and are plotted in curve No. 1.

The ordinates represent the relative migration velocity of the NO<sub>3</sub>- when varying additions of gelatine solution (1 per cent) have been made, as correspondingly represented as abscissæ.

A pure white and well adhering deposit of silver was obtained when the migration velocity of the NO<sub>3</sub> is near zero. Before that, so long as there was less gelatine added than was necessary to bring about this condition, the deposit was loose, brittle and in the form of trees and striæ. It was also distinctly noted that gelatine gathered around the anode in the form of a slimy, gelatinous layer. When more gelatine was added the deposit on the cathode was gray and black, but firmly adherent. The deposit was washed with water, alcohol

<sup>1</sup> Berg und Hüttenwesen Zeitschr., p. 249 (1885).

<sup>2</sup> Trans. Am. El. Chem. Soc., 15, 441 (1909).

<sup>3</sup> Ostwald's Klassiker No. 23, § 4.



and ether, very slightly warmed and after cooling in a dissicator weighed as such. Subsequent heating when the addition of gelatine was more than 2 cc, changed its color which was evidently due to the burning off of organic matter which had deposited along with the silver.

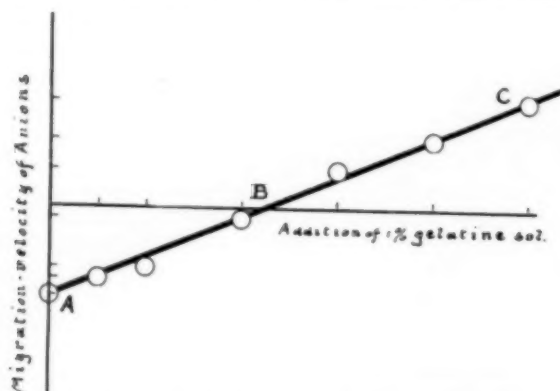
A second series of experiments was performed in exactly the same way and under the same precautions, but varying the conditions in the way of keeping the gelatine addition constant, but varying the concentration of

methods of procedure were exactly identical with those for the first series.

The form of the deposit along part *CB* of Curve 2 is gray and black, gelatine having deposited. At point *B* the deposited silver is pure and stronger heating of the platinum cathode did not cause any loss of weight. Considerable loss was observed on heating the same in the case when lower concentrations of  $\text{AgNO}_3$  solution

TABLE I

Experiment No.	SILVER DEPOSITED ON CATHODE EXPRESSED AS		NO <sub>3</sub> MIGRATED		1% Gelatine Solution Added to 40 c.c. of Electrolyte	Concentration of Electrolyte	n (= Migration Ratio of NO <sub>3</sub> Calc. from Data)	Form and Quality of Deposited Silver on Cathode
	Ag	Ag NO <sub>3</sub>	Expressed as Ag NO <sub>3</sub>	Toward				
1	0.1505	0.2375	0.1360	Anode	No addition	Normal	0.562	Non-adherent forming trees.
2	0.1130	0.1600	0.0865	Anode	No addition	Normal	0.542	The same.
3	0.058	0.092	0.039	Anode	.5 c.c.	Normal	0.445	Vertical striae, badly adherent.
4	0.095	0.151	0.056	Anode	1 c.c.	Normal	0.370	Vertical striae, better adherent.
5	0.178	0.282	0.015	Anode	2 c.c.	Normal	0.053	Pure white, well adherent, smooth.
6	0.114	0.181	0.0425	Cathode	3 c.c.	Normal	-0.235	Smooth, well adherent, slightly gray.
7	0.122	0.194	0.082	Cathode	4 c.c.	Normal	-0.425	The same. Dark gray to black.
8	0.142	0.224	0.149	Cathode	5 c.c.	Normal	-0.665	

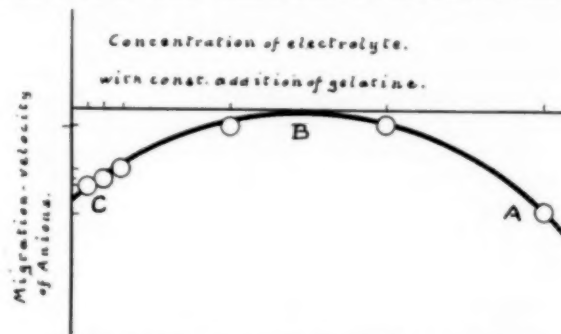


CURVE 1—CURVE OF MIGRATION VELOCITIES

the electrolyte. As constant addition of gelatine was kept that quantity which, with a normal silver solution reduces the migration velocity of the  $\text{NO}_3^-$  to zero. Varying then the concentration of the electrolyte with this constant addition of 1 per cent gelatine solution from 1/10 normal to 3 normal, the results given in Table 2 were obtained. The analytical methods and

TABLE II

Experiment No.	SILVER DEPOSITED ON CATHODE EXPRESSED AS		NO <sub>3</sub> MIGRATED		1% Gelatine Solution Added to 40 c.c. of Electrolyte	Concentration of Electrolyte	n (= Migration Ratio of NO <sub>3</sub> Calc. from Data)	Form and Quality of Deposited Silver on Cathode
	Ag	Ag NO <sub>3</sub>	Expressed as Ag NO <sub>3</sub>	Toward				
1	0.070	0.1105	0.084	Anode	2 c.c.	N	0.240	Gray, well adherent.
2	0.067	0.1057	0.0818	Anode	2 c.c.	1/10 N	0.220	Same Form
3	0.099	0.156	0.1262	Anode	2 c.c.	5 N	0.19	Smooth, slightly gray.
4	0.178	0.282	0.015	Anode	2 c.c.	N	0.053	Pure white, well adherent.
5	0.260	0.409	0.389	Anode	2 c.c.	2 N	0.05	
6	0.222	0.351	0.236	Anode	2 c.c.	3 N	0.328	Striae, not well adherent.



CURVE 2—CURVE OF MIGRATION VELOCITIES

were employed (part *BC* of the curve). Along part *BA* the deposit was pure but with a tendency to form striae and loose deposit.

#### EXPERIMENTS WITH COPPER SULPHATE

Valuable information was expected to be obtained by studying the effect of adding gelatine solution to an electrolyte consisting of bivalent ions; copper sulphate was chosen for this purpose. A further point kept in view was to determine the change of concentration around both electrodes. This, however, cannot be done satisfactorily in the usually employed Hittorf tube above described, and a special tube was constructed to meet with the above requirements. Its diagram is given in

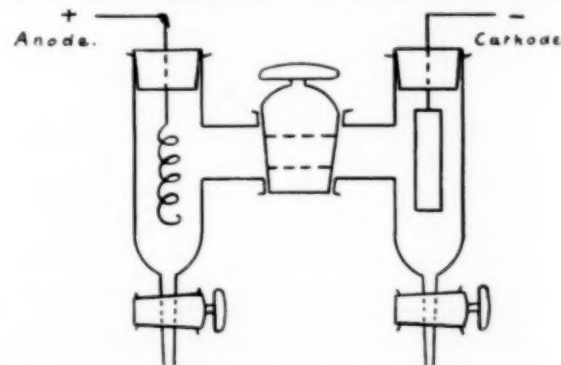


FIG. 2—TUBE FOR DETERMINATION OF CONCENTRATION

Fig. 2 and in use it was found to answer the purpose very satisfactorily.

It consists of two separate compartments for the electrodes, each one provided with an outflow closed by a glass stopper. These two compartments are connected by a side branch connection in the middle of which there is a large glass stop cock. The purpose of this middle large-hole glass stop cock is that by closing the same after the experiment all diffusion can be prevented.

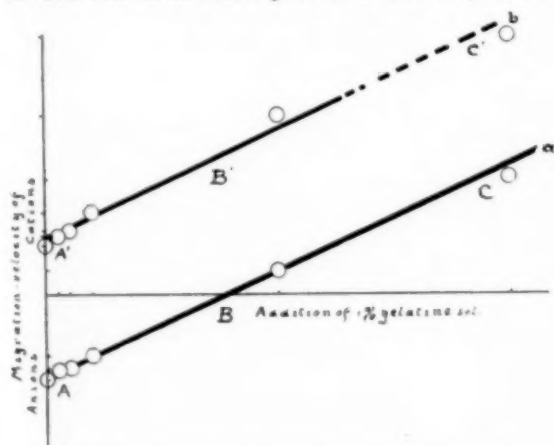
During the experiment the stop cock was kept open and it is, of course, necessary to prevent agitation or disturbance of the apparatus. After the experiment and turning off of this stop cock the electrodes are removed and so the possibility of local action due to stay of the electrodes in the solutions is excluded. Once these precautions have been applied, the contents of the vessels can then be analyzed at leisure. The capacity of this apparatus with the electrodes in position is about 45 cc.

For this third series the technic of analysis was

altered and titration of the copper by KCN solution was found to give satisfactory results. The solution of one compartment was run into an accurate burette for the purpose of determining its volume. From this burette an aliquot volume was run into a beaker,  $\text{NH}_4\text{OH}$  was added until the maximum of blue color was reached and the volumetric KCN solution was run in until the last drop caused the disappearance of the blue color. From this the concentration of the  $\text{CuSO}_4$  was calculated and by comparing this with a blank determination before the electrolysis the change of concentration was calculated.

In weighing of the platinum foil which had served as cathode the same method was followed which is washing with distilled water, alcohol, and ether, very slight warming, cooling in the dessicator and rapid weighing. Hence, in this case also, all organic matter which had deposited along with the copper when the large additions of gelatine were made was weighed and expressed as copper. However, we are now to recall that, when smaller additions of gelatine were made the gelatine gathered around the anode, whereas the cathode remained pure and did not lose any weight on heating. Only then, when larger additions of gelatine were made did stronger heating cause a loss in weight of the cathode. This is also the result of the first series; when there is an excess of gelatine it deposits on the cathode as a black layer.

For this reason the first part of Curve 3 (from A to



CURVE 3—CURVES OF MIGRATION VELOCITIES

B) includes pure deposits of copper and hence represents true migration velocities; from B on, however, the part representing the relative velocity of  $\text{Cu}^{++}$  larger than 1, is not a representation of real migration velocities. Moreover, this illustrates that gelatine takes part in the electrolysis in accordance with its electric charge.

The results obtained in this series are given in Table 3 and are also represented in Curve 3. Comparing the numerical results and inspection of the curves show that they run parallel.

#### DISCUSSION

These experiments lead to the general result that, if to a given concentration of an electrolyte gelatine solution is added in a small quantity, the velocity of migration of the anions is decreased and gelatine, together with the absorbed anions, migrate to the anode. On increasing this addition a point is reached where this gelatine-anion complex ceases to migrate while the relative migration velocity of the cations has become equal to 1. If, finally, this addition is further increased it is found that the complex gathers on the other electrode, the cathode, where it deposits with the metal.

Furthermore, it follows from these data that the

TABLE III

Experiment No.	COPPER DEPOSITED ON CATHODE EXPRESSED AS		$\text{SO}_4$ MIGRATED		$\text{Cu}^{++}$ MIGRATED		1% Gelatine Added to 40 c.c. of Electrolyte	Concentration of Electrolyte	$n = \frac{\text{Migration Ratio of } \frac{1}{3} \text{SO}_4}{\text{Calculated from Data}}$	$1-n = \frac{\text{Migration Ratio of } \frac{1}{3} \text{Cu}^{++}}{\text{Calculated from Data}}$
	Cu	$\text{CuSO}_4$	Expressed as $\text{CuSO}_4$	Toward	Expressed as $\text{CuSO}_4$	Toward				
1	0.038	0.079	0.0514	Anode	0.0304	Cathode	No addition	Normal	0.650	0.380
2	0.067	0.1396	0.0792	Anode	0.0626	Cathode	4 c.c.	N.	0.567	0.448
3	0.075	0.1553	0.0882	Anode	0.0774	Cathode	10 c.c.	N.	0.564	0.495
4	0.042	0.0875	0.0418	Anode	0.0541	Cathode	20 c.c.	N.	0.477	0.617
5	0.067	0.1396	0.0271	Cathode	0.194	Cathode	100 c.c.	N.	-0.194	1.389
6	0.039	0.0813	0.096	Cathode	0.1660	Cathode	200 c.c.	N.	-0.896	2.042

Form and quality of deposit: Streaky, not well adherent in 1, 2, 3, 4

Smooth and pure in 5, 6

\*(In Table 3.) In some of the experiments for curve 3 it has been necessary to add for example 100 or 200 cc. of a 1 per cent solution of gelatine to 40 cc. of electrolyte, which would amount to a considerable further dilution. For this reason a stronger solution was added but represented in terms of a 1 per cent solution. This might slightly influence the numerical results, for, gelatine solutions at different dilutions exhibit different colloidal properties; considering, however, the remarks on this part of the curve, the differences become negligible.

$\frac{1}{2}(\text{SO}_4=)$  requires an addition of gelatine solution which is about 45 times that which is required to cause the same effect on the  $\text{NO}_3^-$ . This ratio can be read off directly from the curve, thus for example, the distance from the ordinate axis to the intersection of Curve 1 is to the same distance of Curve 3 as 1 is to 45.

The phenomenon here observed is not a chemical reaction between the electrolyte or one of its ions and gelatine nor a mechanical mixture, but has all the characteristics of a process called absorption. J. M. van Bemmelen<sup>4</sup> and H. Freundlich<sup>5</sup> show that absorption phenomena between colloidal gels and dissociated crystalloid solutions are phenomena of very frequent occurrence. They also show that, especially if the absorbing substance is an emulsoid, the crystalloid very often is split in parts of which but one is absorbed. J. M. van Bemmelen<sup>4</sup> has compared the absorption phenomena with the distribution of a solute between two immiscible sol-

vents, whereby  $\frac{C_1}{C_2} = f(k)$ , thus  $k$  in the case of a process of absorption is a function depending on a number of factors and not a constant as it is in the case of a solution.

The investigations of H. Freundlich<sup>6</sup> on the absorption of the liquid by the solid phase led to the formula

$$\frac{x}{m} = ac \frac{1}{q}$$

which formula has been applied and is considered as typically representing the process of absorption. The exponent varies little, between 0.5 and 0.8.

The coefficient  $a$ , however, while constant for one and the same substance differs widely, especially with the chemical nature of the absorbing substances. W. M. Bayliss<sup>7</sup> found that its value changes decreasingly with the anion branch of the Hofmeister series.<sup>8</sup> Again H. Freundlich<sup>9</sup> shows that the precipitating power of monovalent ions on positively charged colloidal  $\text{Fe}(\text{OH})_3$  is to that of divalent ions as 1 is to 40 or 50, or about 45. It is also shown that the cations have an influence on this ratio, so that this result is in fair agreement with the results obtained. Whetham,<sup>10</sup> working on the scale of approximation, found this ratio of the power of precipitation of monovalent and divalent ions as 1 is to 40 ( $\text{M}^+:\text{M}^{++}:\text{M}^{+++}::1:40:1600$ ).

4. Zeitschr. f. phys. Chem. 45, 307 (1903).

5. Zeitschr. f. anorg. Chem. 23, 111, 321 (1900).

6. Zeitschr. f. phys. Chem. 57, 385 (1907).

7. Biochem. Journ. 1, 175 (1906).

8. Arch. f. exp. Path. & Pharmacol., 28, 210 (1891).

9. Zeitschr. f. phys. Chem. 73, 387 (1910).

10. Journ. of Physiol., 24, 301 (1899).



The observed effects resulting from the addition of gelatine to electrolytes, therefore, are the same as those that characterize typical absorption phenomena; hence, we may conclude that gelatine absorbs selectively the anions of the electrolyte and that whichever is present in greater quantities, the anions or the colloid, determines the character, such as the electric charge, etc., of the absorption complex.

The investigations of S. E. Linder and H. Picton<sup>11</sup> cleared the nature of migration of colloids under the influence of the potential gradient (cataphoresis). W. B. Hardy<sup>12</sup> observed that the addition of an alkali to a solution of albumin caused the same to migrate to the anode, whereas addition of acid reversed the direction of their migration. Moreover, Wo. Pauli<sup>13</sup> confirmed these results and found that a carefully dialyzed albumin solution did not show any migration of the albumin.

We must, therefore, assume as probable that the colloidal gelatine carried a positive charge of electricity and when absorbing the anions either partly or fully or overneutralized their electric charge, according to the relative amount of colloid present compared with the anions. Evidently at the point where the migration velocity curves of the anions cross the axis of abscissae, the charge of the anions was just balanced by the charge on the colloid, for as reported in this case the colloid and the anions ceased to migrate in either direction.

The nature of the observed phenomenon, therefore, being that of an absorption process we might with J. Duclaux<sup>14</sup> and Malfitano look upon the electrical charge of a colloid as an absorption potential, and if we continue this analogy we would have to look upon a colloidal particle as a complex ion and a combination of an ionized salt with a colloid in a solution as a highly complex electrolyte.

Electrically neutral particles, neutrions or isocolloids are known not to migrate under the influence of the potential gradient. The anions and the colloid having entered into such a neutral union, which at the same time is hardly at all ionized itself are, therefore, rendered unsusceptible to the influence of the electric field, which, it is to say, is at the point where the velocity of the anions has been reduced to zero.

Calling now the mobility of the anions and the cations  $l_a$  and  $l_k$  respectively and  $E$  the current which passes through the cell, then  $\frac{l_a}{l_a + l_k} E$  of it is carried to the anode by the anions and  $E \frac{l_k}{l_a + l_k}$  to the cathode by the cations, hence

$$E \frac{l_a}{l_a + l_k} + E \frac{l_k}{l_a + l_k} = E. \quad (1)$$

From this expression follows, that whatever velocity is lost by one ion is correspondingly gained by the other and that the curves representing the relative velocities of the ions must run parallel. This is realized experimentally in Curve 3.

Again, finding experimentally that the addition of gelatine to the electrolyte causes the velocity of the anions to decrease to zero it follows that,

$$E \frac{l_a}{l_a + l_k} = 0 \quad (2)$$

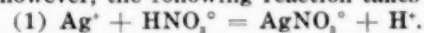
Introducing this in (1) we obtain

$$E \frac{l_k}{l_a + l_k} = E \quad (3)$$

Thus, the cations carry the whole charge of the current and consequently must migrate as fast as they deposit.

The concentration of the cations around the cathode must, therefore, remain unchanged.

From these experiments it is evident that there exists a deposition optimum at the point where the negative charge of the anions is exactly neutralized by the colloid. The isocolloid formed is known not to migrate and so, through continued electrolysis we would obtain an accumulation of isocolloid in the electrolyte. At the anode, therefore, we should not have the regular secondary reaction taking place, which otherwise is,  $\text{Ag}^+ + \text{NO}_3^- = \text{AgNO}_3$  (and  $\text{AgNO}_3 = \text{Ag}^+ + \text{NO}_3^-$  etc.) Instead, however, the following reaction takes place:



The hydrogen ion formed in turn reacts on the colloid and isocolloid in accordance with the following reaction:

(2)  $\text{H}^+ + \text{gelat. NO}_3 = \text{HNO}_3 + \text{gelat.}^+$ ; thus rendering the gelatine once more available to perform its function.

But, in order to liberate all of the bound gelatine, the isocolloid must be brought near to the anode by stirring and it appears as if the force of the electric field to which the electrically neutral particle is unsusceptible must be supplied by mechanical power from a stirring apparatus. In accordance with the above equations, there would be no expenditure in acid nor any of gelatine.

It must be considered, however, that gelatine is a highly complex molecule which, under the strain of the various chemical and electrical treatments would be expected to break down into its component parts. In this sense, then, will there be a slight expenditure of gelatine."

The expenditure of gelatine is considerably greater if the electrical charge of the anions is overbalanced by an excess of gelatine in the acid solution. The particles formed migrate to the cathode and deposit there as the observed black or gray deposit of gelatine. Conversely, if not enough gelatine was added to the bath the gelatine migrates to the anode where it is separated from the acid radicle and forming the observed slimy layer on the anode. Both of these deposits are irreversible and constitute a loss probably in both gelatine and acid.

#### CONCLUSION

The conclusions derived from the foregoing experimental data are:

First.—Colloidal gelatine in an acid electrolyte forms an absorption compound with the anions, thereby either partly or totally neutralizing or reversing their initial charge according to the quantity of gelatine added.

Second.—The gelatine is combined with the anions in such a way that in one case (part A-B of the curve) their velocity of migration is greatly reduced. In another case (point B) their velocity is zero, and in the third case (part B-C of the curve) the direction of their migration is reversed, i.e., the anions migrate to the cathode instead of to the anode.

Third.—Through the decrease of the velocity of the anions the cations gain in velocity proportionally, so that at the point where the anion-migration-velocity is equal to zero the cations carry the full quantity of electricity across the electrolyte. In this way the cations migrate to the cathode as fast as they deposit, and experiments show that at that point only, where the relative migration velocity of the cations is near 1, the metallic deposit on the cathode is smoothest and purest.

This property of gelatine is evidently analogous to

11. Journ. Chem. Soc. 61, 148 (1892).  
12. Journ. of Physiol., 24, 288 (1899).  
13. Beitr. z. chem. Phys. und Path., 7, 531 (1906).  
14. Kolloid Zeitschrift, 7, 73 (1910).  
15. Zeitschr. f. Phys. Chem., 68, 232 (1909).

16. This "breaking down" of gelatine has led a number of investigators to believe in a reducing effect of the gelatine when added to the electrolyte.



the property of certain colloids, which property Zsigmondy designated as their "protective action" or "Schutzwirkung," a property which he has measured quantitatively by the action of such colloids on a colloidal gold solution of an intensely red color. The quantity of colloid necessary to prevent the change of color of 10 c.c. of this red gold solution, which contains a known quantity of gold, over into blue after the addition of 1 c.c. NaCl solution he expressed as the "Goldzahl" or gold number of the colloid. The reciprocal of this "Goldzahl" then expresses the protective action of the colloid upon colloidal gold, which, as we know, also carries a negative charge.

Among a series of colloids gelatine has the value of approximately 200. Gum arabic has the value of about 5; whereas soluble starch has the value of about 0.04. Using these last two colloids instead of gelatine, it was found that their action of neutralizing the charge of anions is proportional to the reciprocals of these ratios.

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## Comparative Furnace Efficiency

BY R. J. WEITLANER

When dealing with heating or melting furnaces in the iron and steel industry the words "efficiency" and "economy" are often used and are still more often confused with one another. It seems therefore pertinent to define these expressions more carefully. We should, for instance, distinguish between "pyrometric" and "thermic" efficiency of a furnace. "Pyrometric efficiency" I call the ratio of heat in metal to the heat in fuel used, or in other words: the ratio of the heat utilized in metal to the heating power of the fuel consumed during this process. This pyrometric efficiency is usually in our mind when we speak of furnace efficiency.

"Thermic" efficiency or "effect" of a flame or a fuel I call the ability of a fuel to develop more or less heat-units in a given space at a time. This is usually expressed as the "intensity" of the flame. If the heat exchange between flame and metal is purely by radiation and not by conduction it is, according to Stefan, proportional to the difference of the fourth powers of their respective absolute temperatures; therefore higher "thermic efficiency" is mostly the cause of a higher "pyrometric efficiency."

Thirdly, if we consider the lower or higher cost of heating or melting we arrive at a third conception, that of "economy." This treats the value of fuels and furnaces from a mere financial standpoint and takes into consideration cost of fuel, labor, maintenance, power, investment and it may be that the latter items (labor, maintenance, etc.) exceed the fuel cost (water-gas).

A few examples may serve to illustrate the practical meaning of these definitions.

Taking, for instance, an ordinary coal-fired heating furnace for billets at a temperature of about 2200 deg. Fahr., we may have an average coal consumption of 450 lb. of coal per ton (2000 lb.) of metal heated. We find the "pyrometric furnace efficiency" from the formula:

$$E = \frac{2000 \text{ lb.} \times 360 \text{ B.t.u.} \times 100 \text{ per cent}}{450 \text{ lb.} \times 14,000 \text{ B.t.u.}}$$

wherein 360 B.t.u. represents the heat-content of 1 lb. of steel at 2200 deg. Fahr., and 14,000 B.t.u. the heat value of 1 lb. of coal. This gives the "pyrometric efficiency"

$$E = 11 \text{ per cent.}$$

The "thermic efficiency" of such a coal-fired furnace as represented by the obtainable flame temperature will be somewhat limited on account of incomplete combustion, excess of air, etc.

If we now replace for this same furnace the method of direct coal firing by the use of powdered coal, we may be able to reduce the coal consumption to 300 lb. of coal per ton of metal. This gives a "pyrometric efficiency" of approximately 17 per cent. This increase in efficiency for the same furnace with the same fuel was only possible through an almost theoretical combustion of the powdered coal and a subsequent higher flame-temperature or thermic effect.

If the cost for pulverizing 1 gross ton of coal amounts to about \$1 and the gross ton of coal costs \$3, we obtain the cost for heating 1 ton of steel as follows:

$$\text{For direct firing } \frac{300 \times 450}{2240} = 60.3 \text{ cents.}$$

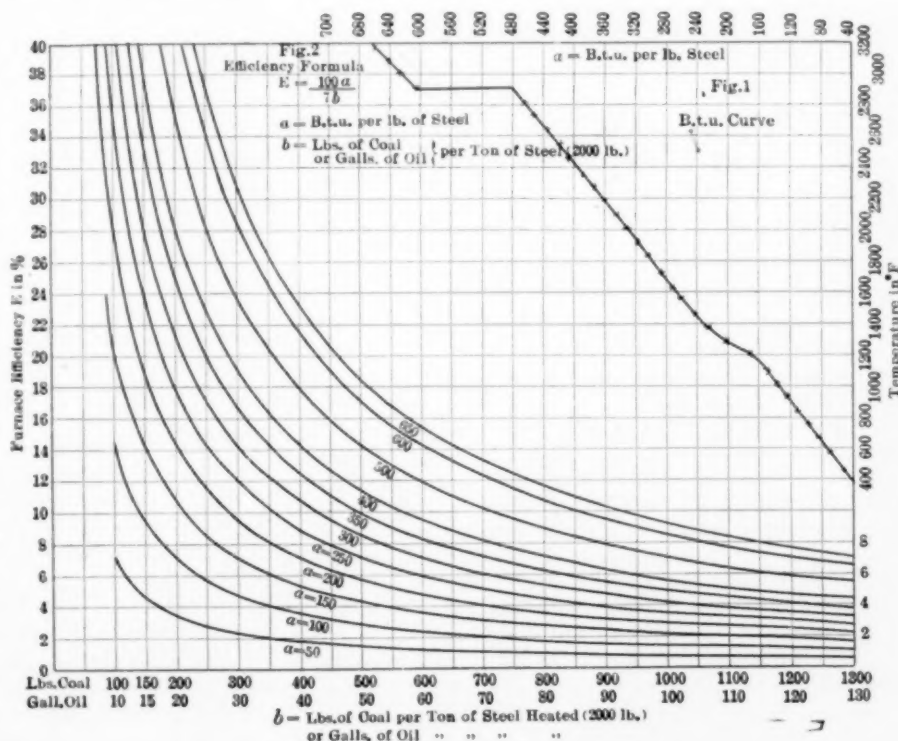


FIG. 1—B.T.U. CURVE. FIG. 2—EFFICIENCY CURVES

$$\text{For powdered-coal firing } \frac{400 \times 300}{2240} = 53.6 \text{ cents.}$$

We see that in this specific case we obtain not only a superior thermic and pyrometric efficiency by the use of powdered coal, but also a higher economy.

Let us further assume that for some reason this furnace should be changed to fuel oil. We know that on account of the concentrated form of this fuel the thermic and pyrometric efficiency will be higher than when ordinary coal firing is used. Here, however, the price

TABLE I.—HEAT-CONTENT IN IRON (J. W. RICHARDS)

TEMPERATURE		HEAT-CONTENT	
°C.	°F.	Cal. p. Kg.	B.T.U. p. lb.
250	482	30.5	54.9
300	572	37.7	67.88
350	662	45.0	81.8
400	752	52.2	93.96
450	842	60.3	108.54
500	932	68.3	122.94
550	1022	76.7	138.06
600	1112	85.0	153.0
650	1202	93.1	171.18
700	1292	111.8	201.21
750	1382	125.6	226.08
800	1472	135.8	244.44
850	1562	144.4	259.92
900	1652	152.8	275.04
950	1742	160.4	288.72
1000	1832	167.8	302.04
1050	1922	175.4	315.72
1100	2012	183.0	329.4
1150	2102	191.7	345.06
1200	2192	200.0	360.
1250	2282	208.3	374.94
1300	2372	216.1	388.98
1350	2462	224.2	403.56
1400	2552	233.1	419.58
1450	2642	241.4	434.52
1500	2732	250.0	450.
1550	2822	258.3	464.94
1600	2912	266.7	480.06
1600	2912	336.0	604.8
1650	3002	346.0	622.8
1700	3092	356.0	640.8
1750	3182	366.0	658.8
1800	3272	376.0	676.8
1850	3362	386.0	694.8

of fuel oil will set a limit to its ability to compete commercially with coal.

Basing the substitution of coal by oil on their respective heat values, we would have 1 gal. of oil equivalent to 10 lb. of coal. But on account of the higher "thermic effect" we assume that 1 gal. of oil is equivalent to 13 lb. of coal. For the oil equivalent to 450 lb. of coal required per ton of steel we therefore get

$$450 \div 13 = 34.6 \text{ gal.}$$

60.3 cents  $\div$  34.6 = 1.74 cents is the price we can afford to pay for 1 gal. of fuel oil, provided no other reasons speak for the use of this fuel.

We may consider it a safe rule to assume that the higher the temperature to which the metal is to be heated the higher the "thermic effect" of the flame must be to insure a fair "pyrometric efficiency" of a furnace.

Through selection of the fuel or of the furnace system we have it to a great extent in our hand to obtain the desired result. This is quite plainly illustrated in an electric furnace. While the electric furnace has the highest pyrometric efficiency of any metallurgical furnace, yet it is more economical to melt the cold charge in an open-hearth furnace and to treat the molten steel afterward in an electric furnace, in which we are able to obtain a wide temperature difference between the molten metal and the electric arc, this fact being so essential for a high pyrometric efficiency.

The writer of this article has tried to bring all the different fuels and systems of firing into certain relations with each other and to develop simple formulas by the use of which we should be able to calculate and compare efficiencies and economies of all kinds of fuels and furnaces.

It must be understood, however, that all the following figures were calculated for special assumed cases and that they are therefore subject to modifications in each particular case, as to the heating value of fuels, cost, etc., and will have to be worked out separately for each locality or plant.

The principle upon which all the calculations and formulas are based is the heat content of the material which was heated or melted.

This heat content as given in Table I is taken from J. W. Richards' "Metallurgical Calculations," page 201,

and gives the heat in iron in calories per kilogram, or in British thermal units per pound at different temperatures. In Fig. 1 a curve is given for the British thermal units per pound of steel as function of the temperature in degrees *F*. For convenience we call this value *a*. Let us further designate with *b* the amount of fuel used in any furnace to bring 1 ton (2000 lb.) of metal up to the temperature for which the heat content was *a*.

From these two items the efficiency and cost formulas for different fuels shall be derived.

#### Coal

According to our definition given before the efficiency of a furnace in per cent is the ratio

$$\frac{\text{heat in metal} \times 100}{\text{heat in coal used}}$$

Assuming an average heat value per pound of coal of 14,000 B.t.u. we have

$$E_{\text{coal}} = \frac{a \times 2000 \times 100}{b (\text{in pounds}) \times 14,000 \text{ B.t.u.}} = \frac{100a}{7b}$$

This simple formula will be of use in most cases where the heat value of coal is not far from the one assumed.

TABLE II.—EFFICIENCIES, WITH VARYING "A" AND "B"

a	°F. Approx.	b=Lbs. of Coal per Ton of Steel (a 2000 Lbs.)									
		100	150	200	300	400	500	600	800	1000	1300
50	445	7.143	4.760	3.572	2.380	1.755	1.428	1.190	.893	.714	.549
100	806	14.286	9.524	7.143	4.760	3.590	2.857	2.381	1.786	1.429	1.099
150	1094	21.429	14.286	10.714	7.140	5.385	4.285	3.571	2.679	2.143	1.648
200	1292	28.570	19.050	14.286	9.570	7.140	5.712	4.760	3.570	2.856	2.198
250	1508	35.713	23.810	17.857	11.950	8.935	7.140	5.950	4.463	3.570	2.747
300	1820	42.856	28.570	21.429	14.330	10.730	8.569	7.141	5.356	4.285	3.297
350	2170	50.000	33.333	25.000	16.710	12.525	9.997	8.331	6.249	4.999	3.846
400	2444	58.100	38.572	29.140	19.420	14.280	11.424	9.520	7.140	5.712	4.396
500		72.60	47.60	35.715	23.800	17.950	14.285	11.905	8.930	7.145	5.495
600	2912	87.143	57.143	42.858	28.560	21.540	17.142	14.286	10.716	8.574	6.594
650	3130	99.04	65.33	49.23	32.335	24.250	19.400	16.167	12.121	9.288	7.143

In Table II the values of *E* are given for varying *a* and *b* and the results are plotted graphically in Fig. 2.

To arrive at an example for cost formulas we assume that 1 gross ton of coal costs \$3 and that 50 cents is the expense of handling it, so that the total cost of 2240 lb. of coal is \$3.50, hence that of 1 lb. 0.1563 cent.

The cost for heating 1 ton (2000 lb.) of steel will be  $C = b \times 0.1563$  cent. From the efficiency formula we

obtain  $b = \frac{100a}{7E}$  and the cost formula is

$$C = \frac{100a \times 0.1563}{7E} = \frac{15.63a}{7E} = \frac{2.232a}{E}$$

This, of course, holds good only for the above assumptions.

#### Producer Gas

Using producer gas as a fuel the combined efficiency of producer and furnace will remain the same, only the cost of preparation will be higher. We assume a cost of \$3.50 for 1 gross ton of gas coal and an additional cost of \$1.25, or a total cost of \$4.75 per gross ton, or 0.212 cent per pound of coal.

$$E_{\text{coal}} = \frac{100a}{7b}$$

(*b* = pounds of coal gasified per ton of steel.)

$$\text{Cost } C = b \times 0.212 = \frac{21.2a}{7E} = \frac{3.03a}{E}$$

#### Powdered Coal

Again we have

$$E_{\text{coal}} = \frac{100a}{7b}$$



Let us further assume the cost of 1 gross ton of gas slack to be \$2.50, and the cost of pulverizing \$1.25, so that the cost of 1 gross ton of powdered coal is \$3.75, or 0.1674 cent the cost per pound.

$$\text{Cost } C = b \times 0.1674 = \frac{16.74a}{7E} = \frac{2.391a}{E}$$

#### Oil

Turning to oil we can establish similar formulas by taking  $b$  in gallons per ton of steel heated and assuming an average heat-value of 140,000 B.t.u. per gallon of fuel oil:

$$\text{Efficiency: } E_{oil} = \frac{a \times 2000 \times 100}{b \times 140,000} = \frac{10a}{7b}$$

In order to obtain the cost formula we assume the cost of 1 gal. to be 2.45 cents and the cost of handling 0.55 cent, hence total cost per gallon is 3 cents.

Cost of heating 1 ton of steel:

$$C = 3b$$

$$b = \frac{10a}{7E}$$

$$C = \frac{30a}{7E} = \frac{4.3a}{E}$$

With varying oil prices we get, for instance,

$$4 \text{ cents per gal.} + 0.5 \text{ cent for handling Cost } C = \frac{6.43a}{E}$$

$$6 \text{ cents per gal.} + 0.5 \text{ cent for handling Cost } C = \frac{9.3a}{E}$$

#### Wood Fired Furnaces

Although of relative low and greatly variable heating value, wood is still sometimes used for moderate temperatures, for instance, in annealing furnaces.

One cord of pine wood weighs about 2000 lb.

One pound of pine wood with 25 per cent  $H_2O$  (air dried) develops approximately 6000 B.t.u.

$$E_w = \frac{a \times 2000 \times 100}{b \times 6000} = \frac{100a}{3b}$$

$b$  = pounds of wood per ton of steel.

We may assume the cost for one cord of pine wood to be \$4, including handling.

1 lb. dry wood = 0.2 cent

$$\text{Cost } C = \frac{100a \times 0.2}{3E} = \frac{6.67a}{E}$$

#### Electric Power

Derived similarly, we obtain from

1 kw = 3412 B.t.u.

$b$  = kilowatt-hours per ton of steel heated or melted

$$E = \frac{a \times 2000 \times 100}{b \times 3412} = \frac{58.617a}{b}$$

with varying prices of 1 kw-hr.:

$$1 \text{ kw-hr. 1 cent: } \frac{58.617a}{E}$$

$$1 \text{ kw-hr. 1.25 cents: } \frac{73.27a}{E}$$

$$1 \text{ kw-hr. 1.5 cents: } \frac{87.926a}{E}$$

After having established these formulas it should be understood that said efficiencies are based only on such a fuel consumption which was necessary to bring the material up to the desired temperature to melt or to perform a certain metallurgical process. This efficiency is termed by Prof. J. W. Richards the "specific efficiency."\* From this we have to distinguish such fuel

consumption as is necessary to keep or "hold" the material at that temperature.

Such cases, for instance, occur mostly in annealing furnaces where the steel, after having been brought up to the desired heat, is kept for a certain period at that temperature. This is called by Professor Richards "generic efficiency" or "holding efficiency" as we may also term it. Even under similar conditions of temperature and "holding time" the fuel consumption will vary with the different furnaces, depending upon their construction, size, form, etc. To compare such generic efficiencies with each other, the fuel consumption  $b$  has to be given in pounds, gallons, kilowatt-hours per hour† and the cost will be figured directly from this fuel.

The fuel consumption per hour in each furnace will, of course, be a function of the temperature at which the furnace is held.

For the sake of comparison, a number of cost formulas were worked out for various fuels, prices of fuel and handling cost and arranged in Table III. Although these figures are merely given for comparison and must be figured for each individual plant they are perhaps not far off from actual practice.

The purpose of preparing such a "cost sheet" was to enable us to compare with one another the cost of heat-

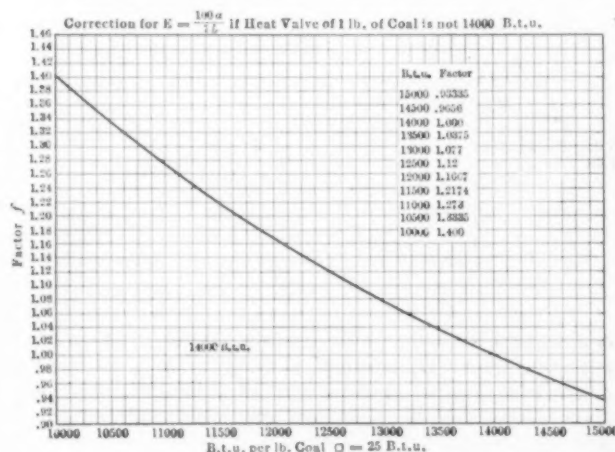


FIG. 3—CORRECTION FACTOR CURVE

ing or melting 1 ton of steel in different furnaces and under different efficiencies, and was based finally upon the temperature of the metal, in other words to make the cost of heating metal a function of its temperature and furnace efficiency.

To express the performance of any furnace by the amount of fuel used per ton metal heated, without paying attention to the heat in fuel and metal, does not give a clear picture of how much of the heat in fuel is actually absorbed in useful work, whereas, if we say, for instance, that a furnace has an actual efficiency of 10 per cent we come to realize at the same time the great amount of heat lost in such a process of heating or melting. We will try to find the causes of such losses and to improve the process.

Of two furnaces having similar construction, one may have a much lower fuel consumption than the other, yet after figuring their respective efficiencies the relation may just be reversed, on account of the poorer fuel value or different temperature of the heated material. The advantage of expressing furnace performances in percentage efficiencies can thus be seen.

Looking once more over the efficiency formulas we find that those for electricity and fuel oil are almost theoretically correct, whereas for those for wood and coal corrections will be necessary if the heat value does not

\*See Richards, Metallurgical Calculations, Vol. I, p. 76.

†See Richards, Vol. I, p. 77.

TABLE III.—COSTS OF HEATING OR MELTING  
One Ton (2000 lbs.) of Steel in Different Furnaces Under Various Efficiencies and Fuel Prices

I. Fuel	II. Efficiency Formula	III. Fuel Costs Including Freight	IV. Additional Costs	V. Cost Formula in Cents	VI. Furnace Efficiencies in %															
					1%	2%	3%	4%	5%	6%	8%	10%	15%	20%	25%	40%	45%	50%	55%	60%
COAL:																				
Direct Fired.	$E = \frac{100a}{7b}$	1 gr. ton = \$3.00 (soft coal)	5 c for handling	1 lb. = .1562c 2.232a = E	2.232a	1.116 a	.744 a	.558 a	.4464a	.372 a	.279 a	.2232a	.1488a	.1116 a	.0893 a					
Powdered ...	$E = \frac{100a}{7b}$	1 gr. ton = \$2.50 Gas Slack Coal	\$1.25 for Pulverizer including interest and de- preciation	1 lb. = .1674c 2.3914a = E	2.3914a	1.1957a	.7971a	.59785a	.4783a	.3986a	.299 a	.2391a	.1594a	.11957a	.09565a					
Gasified, ....	$E = \frac{100a}{7b}$	\$3.50 Gas Coal	\$1.25 to gasify including interest, etc.	1 lb. = .2123c 3.033a = E	3.033a	1.5165a	1.011 a	.7582a	.6066a	.5055a	.3791a	.3033a	.2022a	.15165a	.1213 a					
OIL:																				
	$E = \frac{10a}{7b}$	1 gal. 2.5c	.5c per gal.	4.286a = E	4.286 a	2.143 a	1.4287a	1.0715a	.8572a	.7143a	.5357a	.4286a	.2857a	.2143 a	.171 a					
		1 gal. 3. c	.5c per gal.	5. a = E	5. a	2.5 a	1.667 a	1.25 a	1. a	.8333a	.625 a	.5 a	.3333a	.25 a	.2 a					
		1 gal. 4. c	.5c per gal.	6.43 a = E	6.43 a	3.215 a	2.143 a	1.6.75a	1.286 a	1.072 a	.8038a	.643 a	.4285a	.3215 a	.257 a					
		1 gal. 5. c	.5c per gal.	7.86 a = E	7.86 a	3.93 a	2.62 a	1.965 a	1.572 a	1.31 a	.9825a	.786 a	.524 a	.393 a	.3143 a					
	b=gals.																			
WOOD:																				
	$E = \frac{100a}{3b}$ b=lbs. wood	1 cord Pine Wood \$4.00 incl. handling		1 lb. = .2c 6.67a = E	6.67 a	3.335 a	2.223 a	1.6675a	1.334 a	1.117a	.8337a	.667 a	.4445a	.3335 a	.267 a					
ELECTRIC POWER:																				
	$E = \frac{58.617a}{b}$	1 kw-hr. = 1c.		58.617a = E												1.4663a	1.3032a	1.173 a	1.0664a	.977a
		1 kw-hr. = 1.25c		73.27 a = E												1.8328a	1.629 a	1.466 a	1.333 a	1.228a
		1 kw-hr. = 1.5c		87.926a = E												2.1995a	1.955 a	1.7596a	1.5996a	1.486a

correspond with the value given. Fig. 3 gives these correction factors with which  $E = 100a/7b$  is to be multiplied if the coal used has a higher or lower heating value than 14,000 B.t.u. Similar correction curves can be plotted for wood, etc.

If the metal charged into the furnace has a higher than ordinary temperature,  $a$  will be represented by the difference of the two respective heat contents.

This I think is a good illustration of the usefulness of an efficiency formula instead of expressing the furnace work in the amount of fuel used. In such a case the latter would hardly mean anything to us.

Returning to our cost table, No. 3, a few explanations may serve to illustrate the use of the same. Under columns I and II different fuels and their efficiency formulas are given. In column V the cost formulas were derived from the fuel cost and cost of preparation. This additional cost, on account of being more liable to changes, makes the cost formulas more fluctuating and can therefore be omitted if desired.

Under VI the factors are given with which  $a$  has to be multiplied to obtain the actual cost of heating or melting 1 ton of steel in a furnace whose efficiency was  $E$ .

$E$  in percents is first figured from  $a$  and  $b$  and the cost looked for under  $E$  for respective furnace system and fuel cost.

(1) We readily see, for instance, that an oil-fired heating furnace (with oil at 2.5 cents per gal.) must have an efficiency of 10 per cent to compete economically with a hand-fired coal furnace of about 5, per cent efficiency.

(2) We can also say what price we are able to pay for a certain fuel (for instance oil) to compete with a coal-fired furnace of the same or higher efficiency (which is the reverse of example 1). In both these cases  $a$  was

eliminated since we assumed that the temperature of the steel was the same in either furnace.

(3) Should the heating temperature of a furnace be increased or decreased for a certain period or should a new furnace be constructed of the same design as the one whose efficiency is known to us, but for a different temperature, we have for example:

$$\text{Cost } C_1 = \frac{E_1}{3.033a_1} \quad (\text{See cost formula.})$$

$$\text{New furnace: Cost } C_2 = \frac{3.033a_2}{E_2}$$

If the temperatures are not too far apart we may assume:

$$E_1 = E_2$$

and therefore

$$\frac{C_1}{C_2} = \frac{a_1}{a_2}$$

in other words, roughly speaking, the cost of heating is in direct proportion to the heat content in steel and consequently to the fuel consumption

$$\frac{C_1}{C_2} = \frac{a_1}{a_2} = \frac{b_1}{b_2}$$

This assumption that the efficiencies of one and the same furnace were alike for moderate temperature differences is not correct since the losses by radiation and conduction also increase with higher temperatures and the conditions become quite complicated. It will also be influenced by the range of these two furnace temperatures from the flame temperature which in itself is not a constant.

These were only a few examples to show how this table can be used.

To facilitate this use it will be advisable after fuel



prices for special cases have once been settled, to construct the cost in form of curves, in which either fuel cost or  $a$  can be made variable, similar to the curves in Fig. 2.

**Résumé.**—In the foregoing the writer has tried to bring the question of comparing furnace efficiencies on a more uniform basis by means of the heat content in metal and he has given simple formulas by which this may be easily obtained.

Incidentally these formulas can also be used to develop a uniform system of cost comparison.

Noble, Pa.

## Chemical Engineering in Nitrocellulose Manufacture

BY S. L. STADELMAN

This article bears on modern methods for the manufacture of cellulose-nitrate gun powder or nitrocellulose powder.

We shall avoid as much as possible material which can be gleaned from text-books and other magazine articles on the subject. Machines of standard make and patents on record, beyond merely sketching, will not be described in detail.

The quality of the American product, if we may diverge, is very high. Only one circumstance may mar it, namely, a possible failure in the manufacturing of a sufficiently pure diphenylamine (see Nitrocotton Powder Manufacture, under Mixing). The German product is a clear light yellow, the American is a dirty gray.

Only recently, in the latter part of April, there was recorded a big explosion in a Russian powder mill. We surmise that they are having the same difficulty. The material that exploded was probably nitrocellulose, and also, most likely, in a powder magazine. Rarely does a big explosion occur in a manufacturing plant where everything is run in small units on purpose to limit such possibilities. The Russians use nitrocellulose very largely. Even if it were another material that exploded, the fundamental cause could still be an impure member of the benzol series.

The cost of nitrocellulose powder manufacture, as near as we can judge, is between 35 and 40 cents a pound.

The manufacturing of nitrocellulose powder may be divided into several stages: the treatment of the raw cotton preparatory to its nitration; nitration and purification of this nitrated cotton preparatory to its being made into powder; the making of gun powder from the fluffy nitrated cotton, and lastly, the powder-finishing processes till shipment is made.

The accompanying flow table gives a fair idea of the whole process:

FLOW SHEET

Bales	Nitrated	(Sporting powder (a line by itself))
Picked apart	In Nitration House Wring out Submerged	Dehydrating Block breaking
Treated with alkali		Mixing Re-blocking
Boiled	Boiled in boiling tubs	Pressing
Revolved drum	Pulped	Cutting Waste
Rollled into sheets	Poached in Pouches	Solvent recovered
	Screened	Wet drying
	Blend	Drying
		Coating
		Wet drying
Picked apart	Dried { Some shipped, some made into powder	Drying
Dried	Waste, what becomes of	Glazing
		Blending and packing

## Raw Cotton

For a raw material the shortest-fibered and cleanest, ripest cotton obtainable is used. The shorter the fiber the less the pulping (q.v.) required later to open the cells in order to free possible acid secretions.

The cotton comes in the ordinary compressed bale, which is opened and thrown into a picking or carding machine, where the fibers are picked apart from one another.

The cotton now receives a boiling of about eight hours in dilute alkali solution of about 1 lb. NaOH to every seven or eight gallons of water. The solution is drawn off and another free boiling with fresh water is given the cotton. Besides its dissolving effect on impurities the alkali saponifies the oils and the soap formed removes the dirt.

The cotton is next bleached to remove lignin substances that form unstable nitrates. This is done generally with calcium hypochlorite because of its cheapness. This material requires extra precautions in order to free the cotton of it, which is accomplished by a revolving drum screen through which plenty of water flows. Thus also is the dirt screened out.

In these two treatments care must be taken to avoid severity lest there should be formed either oxycelluloses with their resulting unstable nitro-compounds later, or hydrocelluloses with their different rates of nitration.

In order to obtain a uniform dry fluffy cotton, free of lumps which are hard to dry, it is next forced between heavy rollers and pressed into wide felt-like sheets. Again is the cotton, now in the form of sheets, subjected to a picking process—tearing fiber from fiber.

The cotton next takes about a thirty minute journey on an endless belt through the dryer at a temperature of 105 to 110 deg. C., and is dumped out with less than 1.1 per cent of moisture on an average. Sometimes though it contains 1.5 per cent or even 1.7 per cent, to overcome which the heat is driven upward, causing occasionally rather inconvenient but not seriously dangerous fires. Straightway on the cotton's dumping out it is packed in large tared tin cans, the lids are clapped on to avoid hygroscopic moisture and the cotton is ready for the weigher. The weigher sends each can to the nitrating house containing from 12 to 17½ lb. each of cotton, according to whether a nitro-cotton of high or low nitrogen content is being nitrated.

Regarding products of high nitrogen content or of low nitrogen content it may be said that throughout all the operations greater care and greater precautions are observed in proportion to the amount of the nitrogen content.

The cotton, scrupulously freed of all grease, oil, fat, lignin, water, dirt, etc., is ready for nitration.

## Cellulose Nitrate

## NITRATING

We shall call this nitro-cotton, since it is still cotton-like to the sight and to the touch.

We have now to deal with one of the most important parts of the whole operation, the nitration house and the nitrating of the cotton.

The nitrating house is a four-storied building with plenty of exits to outside fire escapes, plenty of windows to allow air circulation, and draft pipes sucking away the fumes from every fume-generating point. At some points, such as the neck of the nitrating pots, the suction of the draft pipes is shut off or opened by a valve connected to the lid; thus these draft pipes are opened only when necessary. The fumes collected are carried out and sent up a big terra-cotta standpipe, where they are condensed and collected for further use.

A nitrating house holds from four to eight nitrating

units. A nitrating unit has its parts on each floor of the building. On the fourth there is for each unit a vertical motor. The vertical shaft from the motor in passing down through the third story goes through the center of a square in each corner of which is set one of four nitrating pots. The shaft connects on the second floor with the bottom center of an iron basket of a centrifugal wringer. On the first floor or basement is the submerging pot directly under the wringer.

The motor on the fourth floor is under the control of the wringer-man on the second floor. Attached to the motor is a tell-tale indicating the number of charges the wringer runs off. The motor has two speeds: low or about 300 r.p.m., and high or 1100 r.p.m. Taking into consideration that the wringer basket has about 40 in. diameter it will be seen that at the high speed the circumferential velocity is about one and one-half times that of the old usage, or about 210 ft. per second, compared with the old-time usage of 140.

Each nitrating pot on the second floor has two agitators, interlocking with each other and revolving in opposite directions. The agitators have a low-speed of about 25 r.p.m. and a higher of about 60 r.p.m. The agitators are run by overhead shifting pulleys and belts connecting with shafts running lengthways of building and near the ceiling at both sides of the building.

The cotton ready for nitrating comes into the building at the third floor. Along with the proper "acid mixture" running in on top of it and with the agitators on the higher speed, the cotton is dumped into a nitrating pot. After thorough immersion has taken place the agitators are put on low speed.

After nitration the now nitro-cotton and the acid are drawn off by gravity from the pot, through a 6-in. pipe connected to its bottom, and run directly into, but against the side of, the slowly revolving wringer basket underneath. The wringer is speeded and the acid flung to the circumference of the basket runs through the holes therein and is collected in the basement below for future use. For a 12-lb. charge of raw cotton the wringer is run on high for one and three-quarter minutes and for a 30 or 35-lb. charge the wringer is on high for three and one-half minutes.

The acid wrung out, the wringer-man pulls up a valve plate, which surrounds the shaft and closed a circular hole in the bottom center of the basket. Through this hole with a brass-tipped pitch-fork he works the nitro-cotton. It drops directly into the submerging vessel below, where each fork lot is suddenly submerged by a heavy stream of water. From here the nitro-cotton and water are pumped to the boiling-tub house.

The wear and tear on a nitrating building is enormous. Parts for renewal must be zealously kept on hand and constant vigilance maintained against the least sign of a breakdown. As for fires, just as long as a good clean cotton is used they will be a rarity, taking it for granted that no dirt, oil, water, etc., is introduced into the cotton while nitrating and wringing out. It is said that a minute drop of water dropped in a charge when in a wringer will cause a fire.

So much may be said on the mechanical part. The chemical considerations next absorb our attention.

Since some part of the waste acids spoken of above would if revived make the acid holdings on hand more than is necessary, this part is generally used for the manufacture of nitric acid. Oleum is used to revivify waste acids, which use reduces very considerably the loss from excess waste acids. Two or three kinds of fortifiers are used. The use of any special one on a particular case depends upon the kind of nitro-cotton being made, which in turn governs the proportionate loss between the acids in a charge and the water gain of

a charge. On account of the variability of the loss or gain over the rectified acid in the sulphuric acid percentage of waste acids, a strong nitric acid fortifier is added first. This throws the  $H_2SO_4$  percentage below what it should be if it is not already so. Now a 1 to 1, or some such other fortifier, can be used. Another consideration is in so running the waste acid batches that those which cannot be brought back to their original use can be changed to the nitration of another grade of nitro-cotton.

We shall in this article consider only three grades of nitro-cotton. First, a high-nitrogen cotton of from 13.30 to 13.45 per cent. Second, a middle grade nitro-cotton, pyrocellulose, of from 12.45 to 12.75 per cent of nitrogen, or even 18.85 per cent. Third, nitro-cotton of about 12.25 per cent N used as a component of gelatin dynamite.

The temperature of nitration of the high nitrogen material is from 15 to 20 deg. C. That for the lower nitrogens is from 35 to 40 deg. C.

The time of nitration of the high nitrogen material is from fifteen to seventeen minutes. That for the lower nitrogen is about twenty-five minutes, although this is subject to a few minutes shortening. Both times are often considerably lengthened by delays, but without particular harm.

The cotton charge of the high nitrogen material is one can containing 12 lb. That for the low is two cans containing  $17\frac{1}{2}$  lb. each or 35 lb. Sometimes with an unusual fibered cotton 30 lb. per charge is used.

The theoretical yields of the three grades from the raw cotton is as follows: Multiply the raw cotton used by 1.65 to obtain the weight of the output of the high-nitrogen material. For the pyrocellulose multiply by 1.58. And for the 12.25 per cent material multiply by 1.50.

From the foregoing figures it will be seen that the theoretical output of one nitrating unit per day of twenty-four hours is 5702 lb. for the nitro-cotton of high nitrogen, 10,618 lb. for pyrocellulose, and the same for the low nitrogen product. If everything works smoothly the output of the two latter may be increased possibly 3000 lb. more each; since it is not injurious to cut down the time of nitration on them a few minutes. However, owing to breakdowns, etc., in actual practice the output of the high grade is about 4800 lb. a unit per day, and for the others it is about 10,000 lb. The percentage of acid mixture lost is between four and six. However, when the loss runs over 5 per cent, careful search should be made for leaks.

Because of its rough feeding to the nitrating pots, the quantity of acid put in each charge varies between 900 and 1000 lb. But there is no such wide diversity allowed in the composition of the acid mixture itself. We subjoin a typical analysis of an acid mixture used for making high-grade nitro-cotton:

43.00 cc. "total acidity"		1.75 Sp. Gr.	
Actuals			"Totals"
64.40	$H_2SO_4$		66.07
23.94	$HNO_3$		25.03
2.19	$HNO_2SO_4$		
9.47	$H_2O$		8.90
100.00		90.01 "nitrating total"	100.00

This nitrating total is derived by adding together the two percentages indicated by the dotted lines. The right-hand column of percentages is deduced from the number of cubic centimeters of the total acidity and the specific gravity. The  $HNO_2SO_4$ , iron salts, etc., are not reckoned with in this column, therefore the  $H_2SO_4$  and  $HNO_3$  are high and the  $H_2O$  is low. In the "actuals"



column the  $\text{HNO}_3$  and  $\text{HNOSO}_2$  have been determined by nitrometer and by titration respectively, their sum subtracted giving the actual  $\text{H}_2\text{SO}_4$  direct from the total acidity.

The "nitrating total" is the governing consideration. The actual nitric acid is generally figured at 24 per cent for a high-grade nitrating mixture for nitrating high-grade nitro-cotton. But if it runs under or over, then the "totals"  $\text{H}_2\text{SO}_4$  will have to run a corresponding percentage in the opposite direction in order to keep the nitrating total around 90. An acid mixture of this analysis ought to give a product of about 13.37 per cent  $\text{N}$ ,  $\pm 0.07$ .

In the acid mixture used for making pyrocellulose the  $\text{HNO}_3$  is kept close to 19.30 per cent and the nitrating total at 83.75. Sometimes the nitrating total may be run up to 84 when the fiber to be nitrated is coarse or tough. For dynamite nitro-cotton the  $\text{HNO}_3$  is about 26.5 to 27 per cent and a nitrating total of 83.30. This means a low  $\text{H}_2\text{SO}_4$  content.

Regarding the water content the principle is to maintain it as high as compatible with obtaining the desired nitrogen percentage. High water content tends to increase the solubility of the product (see Blending).

On leaving the nitrating house the submerged nitro-cotton is pumped to the boiling-tub house. A tub has a capacity of about 1200 lb. Everyone is familiar with them, with their double bottoms, the uppermost one perforated and with perforated lead steam coils lying between.

After draining off the submerging water and adding fresh, the high-grade nitro-cotton is given five boilings here altogether. The first is for thirty hours, the water is drained off through the perforated bottom, fresh water added, brought to a boil, and boiled for five hours. Three more five-hour boilings follow, changing water each time.

The pyro-cotton receives first a twenty-five-hour boiling, then follow three five-hour boilings, again changing the water each time.

The dynamite-cotton receives an entirely different treatment. In a separate tank especially for the purpose water is heated to 70 deg. C. and no heat or steam whatsoever besides the preheated water is allowed in the tubs where the dynamite cotton is. The first steeping with this 70 deg. water is for one hour. The water is run off and more pre-heated water added. This, the second steeping, is for two hours, the third steeping is for three hours, the fourth is for twenty-four and the fifth is for twenty. Ten pounds of  $\text{Na}_2\text{CO}_3$  is added to the first steeping water.

Counting all the times of boiling, draining off, filling up with fresh water and bringing the water to boil, the sum in the case of high grade is about 64 hours, for pyro-cotton it is about 52 hours and for dynamite cotton it is about 55 hours. To these times ought to be added about 4 to 5 hours more in each case to have a fair idea as to how long a charge of each grade is in the building.

A fair amount of nitro-cotton is strewn about tubs on the floors of the building and becomes waste. It is collected and thrown into a tub by itself. Eventually it follows through the same treatment as the pyro-cotton till it joins the sporting nitro-cotton in poacher house. It finally ends as sporting powder (q. v.).

In draining the boiling waters from the tubs through the perforated bottoms, material is again lost. Big settling troughs, through which the waste water is led, are built to collect this material. After a sufficient quantity has collected, it usually is sent direct to the sporting nitro-cotton poachers in poacher house.

About this stage the future blending is beginning to

be looked after. A careful tracer kept of every tub lot of nitro-cotton shows, by referring to the analysis of acid mixtures as per number given on card, and referring also to the characteristics of the cotton, etc., etc., about what percentage of nitrogen the nitro-cotton will have. On this basis it is generally several tubs of high nitrogen pyrocellulose (about 12.70 to 12.80 per cent) which are selected for the future blending. Outside of giving the pyrocellulose in these tubs one hour less pulping (to be known as seven-hour pyrocellulose) it is not treated differently from ordinary pyrocellulose used for cannon powder.

After these boiling treatments the nitro-cotton is, after draining, forked out of the tubs into high-sided cars and delivered to the pulping house.

#### PULPING

The pulping machine used is the same as is employed by paper manufacturers. A pulping machine or "beater" will have about one-fifth less capacity when pulping nitro-cotton compared with paper pulp. The horsepower required is considerably greater.

The washer connected with the beater carries off a good deal of fine nitro-cotton in liquid suspension. This liquid is run into large circular settling vats of iron. The waste from the floors is also dumped into the settling vats. In fact, they are the recipients of a great deal of waste from various sources, as we shall see as we go along. What is done with this waste will be told under sporting powder.

The beaters are set down in the floor, which makes it easy to dump the nitro-cotton from the cars into them. During the course of the pulping of a charge enough  $\text{Na}_2\text{CO}_3$  is added to make a slight alkalinity.

The high-grade nitro-cotton is pulped twelve hours—rarely less. This length of time is allowed it so that it may be fine enough to incorporate well in the colloid (see mixing) so that it can more easily pass through the fine screens of the macaroni press. In pulping to such fineness care must be taken that the material becomes not so fine as to clog seriously in the dehydration press (q. v.). This is overcome somewhat by allowing its co-constituent (seven-hour pyrocellulose) to retain some of its coarseness by not pulping it so much.

Pyro-cotton is pulped eight hours ordinarily. Dynamite cotton is pulped for eleven hours. Boiling water cannot be used on dynamite cotton at any stage; therefore, it must be well pulped to assure freedom from acid, salts, etc.

In the pulping of high-grade and pyro-cottons we do not know of any case where hot water is in use, although it is supposed to be a considerable advantage.

From the beaters the pulp-filled water is pumped through pipes to the poachers.

#### POACHING

Poachers are large, deep, round wooden tanks with facilities for introducing steam into them, for draining the water from the top downward and for stirring the charge. They have a nitro-cotton capacity when in a desirable thickness of water suspension, of about 7000 lb.

When a poacher is first filled the charge is allowed to settle, the supernatant water drained off and clear water added. High-grade nitro-cotton receives four five-hour boilings. Twenty pounds of  $\text{Na}_2\text{CO}_3$  is added the first boiling and 15 lb. the second. The stirring is kept up during the boiling. After the boiling the high-grade has ten cold-water washings. Each washing is stirred for a half hour.

Pyro-cotton is treated according to the U. S. Government specification (see page 191 of "Military Explo-

sives" by Weaver, 3rd edition), except that 35 lb. of  $\text{Na}_2\text{CO}_3$  are added the first boiling. The sampling and testing is carried out substantially the same as described in Weaver's book, page 192.

Dynamite-cotton receives ten cold-water washings only. All washings from this and the other nitro-cottons are run into the big iron settling vats.

It is in the poachers that one of the two principal blendings is done. The object of blending is to obtain a product of definite qualities, but the blending at this stage is made necessary by the desire to obtain a small-arms colloidal powder high in nitrogen content. Nitro-cotton of 12.85 per cent nitrogen can be made that will be soluble in a mixture of thirty-six parts alcohol and sixty-four parts ether, and a colloid powder be made of it, but above this percentage of nitrogen the solubility rapidly decreases till at 13.40 per cent N only about 8 per cent + is soluble. Now, to obtain a powder of 13.20 per cent N, the 8 per cent soluble high-grade is blended with the entirely soluble pyro-cotton (seven-hour pyro) to make a mixture of about 29 or 30 per cent soluble, which is enough to give when treated with ether-alcohol, a good colloidal body which will encase the non-colloids.

Also in blending it is not desirable to attempt to cut down on the quantity of the non-colloids. They should rather be maintained as nearly as possible at a definite percentage, for it is the presence of these fine detonating particles which gives the powder extra explosive force.

The mechanical part of the blending is done simply by taking a predetermined weight of wrung-out seven-hour pyrocellulose and dumping it into a poacher of high-grade nitro-cotton containing a known weight and stirring them thoroughly together.

#### DRYING

Centrifugal wringers are again made use of, this time to drive out the water. The rather thick water and nitro-cotton is pumped over the wringer through a pipe line which has side connections easily handled by the wringer man. Again the waste water goes to the iron settling tanks. The wringer baskets are much smaller—possibly 8 in. less in diameter—than those in the nitrating house; consequently their circumferential velocity is much less although they make the same number of revolutions per minute.

With the high-grade—now, a high-grade and pyro blend—and the pyrocellulose it is desirable to wring the water content down to as low as 30 per cent. The lower the water content the greater the saving of alcohol in the dehydration. With seven-hour pyrocellulose and dynamite cotton it is not so necessary. The first goes back to a poacher, anyhow, and the latter has to be only dry enough for a drying barrel to handle it.

The blend of high grade and pyro and the pyro are forked through the bottom of the wringer into a blending barrel. When full the barrel is turned over a few minutes, opened, and the contents dropped into a car. Thence they are hauled to steam-heated storage sheds and are ready for dehydration.

Occasionally the pyrocellulose is taken out of its cars, put into a packing press, pressed into oblong blocks, packed in zinc-lined boxes and shipped as pyrocellulose.

The dynamite cotton, after dumping in cars, is taken to a large revolving drying barrel where it is dumped in and dried till the moisture is brought down to 25 per cent. From here the dynamite is sifted through a large mesh screen, pressed into zinc-lined boxes and is ready for shipment to a dynamite manufacturing plant.

#### SCREENING

In pumping the mixture of water and nitro-cotton from the poachers to the wringers or from one poacher

to another according to exigencies it is screened to take out the knots, the larger sized fibers, sticks, dirt, etc. The bottom of the screen is vibrating up and down and is made of metal full of short, narrow slits.

#### Manufacturing and Finishing

##### SPORTING POWDERS

We now come to a branch which is practically by itself.

We have had occasion before to speak about big, round iron settling vats. It will be remembered that the very greatest bulk of this was that which crept through because of its fineness. In fact, it is so fine that alum has to be used to insure its settling to the bottom of the vats. This fineness is what fits it for sporting powder. The nitrogen in this low-grade nitro-cotton runs about 12.40 per cent.

After a vat is full the fine nitro-cotton settled and the supernatant water drawn off, the nitro-cotton is pumped with a little water into a poacher. Here it is given two five-hour boilings, followed by the customary ten cold-water washings. Thence it goes to the wringers and is wrung out to about 38 per cent  $\text{H}_2\text{O}$ . After adding enough high-grade nitro-cotton to it to bring the nitrogen to about 12.50 per cent, it is ready for turning it into powder.

The principle of a sporting powder is simply to make grains of nitro-cotton, which on the outside are hard and impervious, yet have somewhat the explosive effect of uncolloided nitro-cotton.

The manufacture of E. C. powder is familiar and we do not know of any improvement on its manufacture within recent years. Some firms use Chilean saltpeter instead of the potassium salt, which is apparently a good idea, since the grains are water-proof. Aurine is still used in the coating and ether-alcohol in the gelatinization of the water. The speed of revolution of the nitro-cotton granulating drum regulates the size of the grains.

Another powder is made somewhat as follows. The nitro-cotton is held in suspension in a solution of 6 per cent calcium nitrate and 20 per cent potassium nitrate by bubbling upward through it a mixture of benzene ( $\text{C}_6\text{H}_6$ ) 60 per cent and amyl-acetate 40 per cent. The size of the grains formed depends on the rate of the bubbling. The grains must have a certain weight and size and be granular and round. The whole solution with grains is carried over and screened. The amyl-acetate and benzene are recovered by distillation.

Frequent ballistic tests are made of this powder.

##### DEHYDRATION

In the process of dehydration all materials are tested alike except that sometimes an exceptional or say a balky lot may be filled with a different quantity of alcohol preparatory to using a different quantity of ether in the mixing house, thus using a differently proportioned colloid mixture.

The principle of a dehydrating press is as follows: The nitro-cotton is dumped in and pressure applied to drive out as much water as permitted by the space demanded by the quantity of alcohol that is wanted in it. Ordinarily this pressure is about 3000 lb. Finally alcohol introduced under pressure at one end drives the water ahead of it out of the other end. The pressure is broken, the alcoholic nitro-cotton cake is released, test-weighed and canned immediately to avoid evaporation.

From the storage sheds (see Drying, 3d paragraph) the cars of nitro-cotton are put directly in the dehydration house. A definite quantity, enough to make 40 lb. of dry nitro-cotton, is weighed and dumped into the press. If the weight of this, including the water con-



tent, is 57 lb., then  $7\frac{1}{2}$  to 8 gal. of alcohol will be required to dehydrate it. If the weight is 61 to 63 lb., then about 10 gal. are required. This shows the value of a low water content. It saves steam and the wear and tear on the apparatus in the recovery by distillation of the alcohol.

The time of a complete cycle of the dehydrating press is about three minutes and fifteen seconds to three minutes and thirty seconds. It has been brought down to an average of two minutes and forty seconds. These operations (see also macaroni presses) depend so entirely upon the working conditions and the momentary efficiency of the plant that it is hard to give definite data.

Although the U. S. specifications allow the use of alcohol as low as 92.3 per cent by weight, yet the usual strength is 95 per cent. The quantity of alcohol left in each dehydrated block is between 12 and 24 lb., according to what might be called the "workableness" of the nitro-cotton that is being handled at the time. The average quantity of alcohol left in it is about  $16\frac{1}{2}$  lb.

#### BLOCK BREAKER

The alcoholic cakes or blocks of nitro-cotton have to be broken up and rather finely sifted so that they will colloid better in the mixers. The block-breaker does this work. It doesn't need be described. The workmen break up the blocks and small lumps on the floor, which is lead covered.

#### MIXING

A mixer charge comprises, with the 60 lb. or more blades is familiar to everyone. The mixers are surrounded by a cold-water jacket to prevent overheating. But the coldness of the water has also a great effect on colloidization—cold accelerates colloidization and helps to colloid nitro-cotton otherwise not colloidable, and it should be allowed for accordingly. To prevent evaporation of the solvent there is a heavy air-tight lid. The whole mixing machine with its charge is so arranged that it can be dumped of its contents.

At the side of and above a mixer is a small scale with a tared container on it for the weighing of the ether. In this ether there has been dissolved diphenylamine in sufficient quantity to leave one-half of one per cent of it in the finished powder. Diphenylamine is, as everyone knows, the stabilizer. Its agency is to absorb the acidic decomposition products of the nitro-cellulose, thus preventing their deleterious effects, and also, by not permitting their escape, it helps to maintain the ballistics of the powder.

A mixer charge comprises, with the 60 lb. or more of alcohol impregnating it, 200 lb. of nitro-cotton in cans fresh from the block breaker. Enough ether, while the mixer is running, is added to make up at least 64 per cent of the total solvents used, allowing for alcohol evaporation. The mixing is continued thirty minutes or more till the material is suitable for the macaroni presses. To tell when this stage has been reached takes an experienced man. Speaking for himself the author must say that although he has examined these charges repeatedly, yet he can hardly give specific rules to govern telling when this stage is reached. The lumps must have homogeneity—no uncolloided material inside—and there is a certain general consistency which is the outcome of so much solvent on so much soluble nitro-cotton. Sometimes an operator is not satisfied and he adds more ether. Rarely, although it would not be necessary if properly blended, acetone in small percentage is added to increase solubility. Nitro-cellulose powder colloided with acetone is apt to have irregular pressures.

So far we have described the mixing as if the high-grade pyrocellulose mixture and the pyrocellulose nitro-cottons were treated alike. This is so, with the exception that graphite is incorporated in the high-grade pyrocellulose mixture. This is the material of the higher explosive force and is used only for making small arms powder, which means it is made into very small grains. These small grains, unless they had some such material as graphite to make them conducting, would become charged with static electricity which would make them inconvenient for handling and for examination. The larger grains for the larger calibred guns are coated later with graphite.

#### REBLOCKING PRESSES

The charges from the mixers are first taken to a press where they are pressed into an easily handled cylindrical shape of the right diameter to fit the macaroni presses. The whole mixer charge is not pressed into one block, but into two or three, all of which make a macaroni press charge.

#### MACARONI PRESSES

##### (GRAINING PRESSES OR FINISHING PRESSES)

Ordinarily these presses are horizontal. At the end through which the colloid is pressed is a heavy perforated plate set in a heavy band locking door on hinges. This door swings open and the charge is put in and before closing a fine copper screen, of about 60 mesh, we should judge, is put on the inside of the perforated plate.

The colloid is forced through the fine copper screen, through the perforated plate, then through ten to twenty dies, and is carried away from each die by a downward sloping smooth tin tube which coils up the now string-like (although for big guns some is rope-like) colloid in the bottom of round boxes. When a box is filled, it is delivered to a cutting machine and another box is substituted in its place.

It is hard to describe a die and to give a good idea of how it works. The part of the die nearest the press consists of a small round perforated plate, from the center of which, outward and away from the press, projects a needle—to take a simple case—clear through the center of a funnel. A cross-section is shown in Fig. 1.

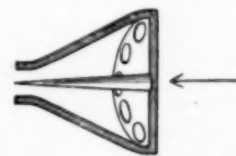


FIG. 1—SECTION OF DIE

The arrow indicates the direction of flow. The colloid squeezed through the holes in the perforated plate is compressed around the needle in the funnel chamber and on going through the outlet it has the desired hole lengthways throughout the center.

The area of the holes in the die must be at least one and one-fourth times the area of the cross-section of the die, lest the part compressed in the funnel should not be thoroughly enough compressed, resulting in an imperfect grain. The initial pressure on these presses is about 2700 lb. and the pressure mounts to about 3300 lb. at the end. A wide divergence is an unfavorable indication of the quality and purity from dirt.

By the output of these presses may be judged the efficiency of the whole plant. By "output" is meant quantity and quality. True, other operations are yet to follow, but they affect the output not so much as the prior operations, and neither do they indicate so well as the presses the quality of the prior operations.

The efficiency capacity of a press is about sixteen charges for twenty-four hours working time, but such an output is obtainable only by the exercise of high intelligence by every man connected with all the prior

operations. If the output of the presses be on an average of thirteen and one-half charges every twenty-four hours it could be classed as highly satisfactory. Ordinarily the run is nine to eleven charges. These figures for efficiency capacity apply to the output of a press that is pressing small-arms powder. For larger arms the output mounts as high as four times the above figures.

#### CUTTING MACHINES

In this machine the colloid strings, coiled up in round boxes and fresh from the presses, are fed between rollers, then through guiding holes, immediately on the far side of which they are cut into definite length grains by knife-edges set in the periphery of a revolving disk. The speed of the feeding, which is rarely varied, and the speed of the disk govern the length of the grains. The proportion of the parts of the grains is specified in the United States Government's tests. The sizes of the grains required to meet the specifications for the muzzle velocity desired and maximum pressure allowable is a subject beyond the scope of this article. However, we understand there have been one or two good books recently published on interior ballistics.

From the cutters the grains are collected in bags and sent to the solvent recovery. With the bigger grains it pays, even while the grains are collecting, to make arrangements to save the large amount of solvent evaporation from them.

From the presses and from the cutting machines there is a considerable waste of colloid nitro-cellulose. It is thrown into covered cans and when a sufficient amount has accumulated it is put in a small mixer, specially used for this purpose and mixed over again.

#### SOLVENT RECOVERY

The solvent recovery building is a long building with many brick fire-limiting walls. With handy connections, there are in each section pipes carrying warm air and other pipes carrying a refrigerating mixture. In each section is a narrow-gage track.

The solvent recovery cars are specially constructed. They are rendered vapor-proof by water sealing of the lids. Lengthways of one side is an air-warming apparatus which causes the air to rise on that side. The air flows over and down among the powder grains collecting the ether and alcohol vapors on its way. At the bottom the air strikes refrigerating coils and promptly gives up its vapors. The powder is in shallow trays, with copper screens on bottom, and set one on top of the other. The recovery process is continued till the small amount which would be recovered does not pay.

The ether and alcohol mixture that is recovered is sent back to the ether house, treated with  $H_2SO_4$  and all made into ether.

#### WET DRYING

It sounds rather paradoxical to speak of wet drying, but the idea is to maintain the powder under water at 65 deg. C., in order to "boil" out the ether and alcohol mixture the more effectively. The principle of using cars is employed again, but the powder is set in deep copper screen baskets. What the length of time of this treatment is we don't know. It is probably not very long.

#### DRYING HOUSE

Here the water is dried off the grains.

#### COATING MACHINES

These give each grain a coating of trinitrotoluol. Which one of the trinitrotoluols it is we are uncertain.

This matter of coating the grains has a great deal of significance. There are probably three or four reasons for doing it. If, as it seems to be, America, by such a simple expedient, improves nitro-cellulose powders, without the addition of injurious ingredients, then we can claim some originality for ourselves. What England has attempted to do in her cordite and France in her nitrate powders, America does in a simple manner.

#### WET DRYER, DRY HOUSE, GLAZING BARREL

We have now another wet-drying process, this time to take out the solvent used in the coating process. It must have been a rather heavy coat which was applied in the coating process.

Again the water is dried off in a dry house.

The glazing barrel is used for glazing every grain with graphite.

Graphite has two uses; it protects the grain from sudden shock, and makes a conducting skin to carry off static electricity caused by friction of the grains over each other. Sometimes, before this skin is put on, the powder will take fire in an inexplicable manner.

#### BLENDING AND PACKING

The high-grade and pyrocellulose rifle powder blends are blended in the poachers as we have seen. The pyrocellulose cannon powders have so far come through with a percentage of nitrogen running between 12.45 and 12.75. The scheme is to blend these powders to meet the government specifications of 12.60 per cent,  $\pm .01$  per cent. After taking two lots of powder and calculating the proper proportions in which to mix them, this is done by putting those proportions of the powders in a square wooden funnel with an opening at the bottom. This opening is opened and the powders are allowed to run into another wooden funnel beneath. This in turn is opened, running the powder into another funnel, etc., till the powders are thoroughly mixed together, or about three or four times altogether.

Regarding packing, see United States Government specifications.

### Library Service Bureau of United Engineering Societies

The United Engineering Library (Engineering Societies Building, 29 West 39th Street, New York City, 12th and 13th floors) is installing a Library Service Bureau along the lines of the former Library Service Bureau of The Chemists' Club. For the purpose of inaugurating this service, the three founder societies of the mining, mechanical and electrical engineers will provide the necessary funds, but the bureau is expected to become self-supporting.

The object of the bureau will be to place the facilities of the United Engineering Library at the disposal of anybody anywhere. Its work will consist in supplying reference cards on articles published anywhere on any special technical subject desired, in supplying copies of articles or of parts of books, in translating articles from foreign languages, making searches on any technical subject, etc. This work will be done at cost. Mr. E. Gybbon Spilsbury is the chairman of the "Library Service Committee" which will act in advisory co-operation with the executive committee of the library board of the United Engineering Society, of which Dr. Samuel Sheldon is the chairman.

Burma is the principal tungsten-producing country of the world, the United States coming second with about half the Burmese production. The bulk of the domestic output comes from Boulder county, Colorado.



## The Relative Efficiency of Various Amalgams in the Recovery of Gold

BY FRANCIS A. THOMSON AND ROBERT KEFFER

In these days of the almost universal cyanidation of gold ores, the ancient and honorable process of amalgamation would appear to have been relegated to the rear. This is truer, however, of the literature of gold metallurgy than of the practice of the art, for we find that in 1913 21.5 per cent of the gold production of the United States was recovered by amalgamation.<sup>1</sup>

It would seem, therefore, that although somewhat unusual and contrary to the present vogue, one need make no apology for a discussion of certain important principles involved in the recovery of gold with the aid of mercury. Many years ago C. H. Aaron<sup>2</sup> stated that he had investigated zinc and cadmium amalgams and had found cadmium-amalgam especially to be remarkably free from tarnish under conditions where mercury-coated copper plates were quickly discolored.

This was the starting point of the investigation here reported. It was thought well, however, to extend the research to include a determination of the efficiency of various amalgams from the point of view of gold recovery, as well as of resistivity to film formation.

The senior writer of this article suggested the investigation and in a general way guided the research; he has also edited the report for publication. Further than this he disclaims any credit for the work done or the conclusions drawn.

As the first step in the investigation a number of amalgams of the commoner metals were prepared. These were then placed in turn on copper plates and the ore passed over the amalgamated plates a standard number of times under standard conditions. Samples were taken of the pulp during the first, third and fifth passage over the plates, and the samples were assayed to determine the amount of gold removed. The difference between this assay and the assay of the original ore was considered the extraction in each case.

Two tests were made to determine the number of passages over the plates necessary to secure the maximum extraction. The ore was run through the apparatus ten times and samples taken during alternate runs. In both cases no further change in the assay of the tailings took place after the fifth passage so the succeeding tests were run through only five times.

To further investigate the properties of the amalgams, a series of tests was made under difficult conditions. The ore was mixed in turn with manganese sulphate, zinc sulphate and ferrous sulphate, and each mixture passed over the plates five times. Two samples were taken—after the third and fifth passage—and assays were made as in the first series of tests. The sample of the first passage of the ore was omitted in these tests, as it had previously been found that little gold was removed by the initial run over the plates. A sulphide ore was also tried with a number of amalgams, but it gave such small extraction and yielded such inconsistent results that further tests along this line were abandoned.

### Preparation of Amalgams

The common metals that amalgamate with ease are: gold, silver, zinc, tin, cadmium, lead and bismuth.<sup>3</sup> With the exception of bismuth and with the addition of sodium, potassium, aluminium and magnesium these metals constituted the list selected for the tests. Of

these, potassium, aluminium and magnesium yielded amalgams of such an unstable nature that they were unsuited for use on the plates. The tests were, therefore, confined to the remaining seven metals. The method of preparation employed varied greatly and each metal will therefore be discussed separately.

1. **Silver Amalgam.** The silver amalgam was prepared according to the method given by Richards.<sup>4</sup> The reaction was practically complete in twenty minutes and the final amalgam (composition, silver 32 per cent, mercury 68 per cent) was a thick paste.

2. **Gold Amalgam.** The gold amalgam was prepared by dissolving pure gold, beaten into thin plates, in boiling mercury. It was found that the gold dissolved very slowly at ordinary temperatures, but went into solution in a few minutes when the mercury is near its boiling point. Fifty grams of mercury were used with 4.121 grams of gold and the resulting amalgam was pasty. On standing a very thick amalgam settled in the bottom of the tube, the remainder being perfectly liquid.

3. **Sodium Amalgam.** In the preparation of sodium amalgam 100 gm. of mercury were warmed in a casserole, and sodium metal added in small pieces, about the size of wheat grains. The sodium combines violently with the mercury, with evolution of yellow light; but as more sodium is added the reaction decreases in violence. Towards the end the mercury must be heated to boiling and the sodium stirred in. A total of 5.4 grams of sodium was required to saturate the mercury. On cooling the amalgam becomes hard and brittle, breaking with a rough fracture. It is soluble in mercury in any proportion and keeps indefinitely in a tightly corked bottle.

4. **Potassium Amalgam.** The potassium amalgam must be prepared in a test tube or other vessel with a narrow opening, which exposes but little surface to the air. In an open dish the potassium is oxidized to a greenish powder, practically as rapidly as added. The reaction between potassium and mercury is much less violent than that with sodium and the mercury must be hot to start the combination. The potassium was added in small, clean pieces, about the size of wheat grains and combined readily with the hot mercury with flashes of violet light. Towards the end of the reaction violent stirring and a temperature about the boiling point of mercury were required to cause combination. The mercury required 5.1 grams of potassium per 100 grams mercury for saturation (at boiling point of mercury). On cooling in the closed tube the amalgam hardened to a solid mass. When the cold amalgam was exposed to the air by breaking the tube decomposition set in immediately. The potassium oxidized very rapidly, occasionally with flashes of flame, forming a dull, greenish powder and liberating mercury. On account of its unstable nature this amalgam was not used in the tests.

5. **Lead Amalgam.** This was prepared by dissolving pure lead foil in warm mercury. It went into solution very readily, yielding a homogeneous fluid, which solidified to a pasty mass on cooling. On standing several hours the amalgam showed a marked tendency to separate into a thick, pasty amalgam and a very fluid amalgam, in a manner similar to gold amalgam. Composition—lead 50 per cent, mercury 50 per cent.

6. **Tin Amalgam.** Tin amalgam is prepared by dissolving tin foil or granulated tin in warm mercury. It resembles lead amalgam in its properties, except that it showed no tendency to separate as in the case of lead amalgam. Composition—tin 43 per cent, mercury 57 per cent.

<sup>1</sup>Mineral Resources 1913, Part I, p. 882.

<sup>2</sup>Eng. & Min. Jour., Vol. 48, p. 118.

<sup>3</sup>Schnabel. Handbook of Metallurgy. Vol. II, p. 254.

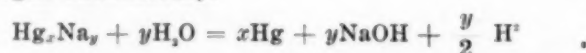
<sup>4</sup>Richards. Textbook on Ore Dressing. p. 114.

7. **Zinc Amalgam.** This amalgam was prepared by grinding 20-mesh powdered zinc in an agate mortar with mercury. Forty grams of zinc were dissolved in 100 grams of mercury, after about two months grinding. On standing the amalgam solidified to a hard, brittle mass, readily soluble in warm mercury.

8. **Cadmium Amalgam.** Pure cadmium in the form of  $\frac{1}{4}$ -in. sticks was dissolved in warm mercury. The cadmium went into solution very readily, being completely dissolved in five minutes. On cooling, the amalgam solidified to a hard, brittle, crystalline mass, which broke with an uneven fracture. It is very stable. Composition—cadmium 32 per cent, mercury 68 per cent.

9. **Aluminium Amalgam.** This amalgam was prepared with considerable difficulty. The usual methods of preparing amalgams were tried without success. The aluminium, in the form of dust minus 150-mesh, was boiled in mercury, but did not combine. Prolonged grinding with mercury in the agate mortar was next tried and failed to form any amalgam. The mercury was then heated with aluminium powder and dilute hydrochloric acid over night, without results. A quantity of aluminium strips was melted in a muffle at about 700 deg. Centigrade and the molten metal poured into cold mercury. This resulted in the formation of considerable liquid aluminium amalgam. The amalgam produced by this means was very unstable and, on cooling, a film of alumina formed over the surface and rapidly increased to a thick, fluffy coating.

To determine whether this instability was an inherent property of the amalgam or due merely to the high temperature of formation by addition of molten aluminium, a second lot of amalgam was prepared cold by treating sodium amalgam with a suspension of aluminium powder in water, as mentioned by Schnabel for the preparation of iron amalgam.<sup>8</sup> On standing twelve hours the sodium amalgam was completely decomposed with formation of sodium hydroxide and liberation of hydrogen and mercury.



The liberated mercury combined with the aluminium to form aluminium amalgam. This amalgam was divided into two parts. Part 1 was tested qualitatively for aluminium and showed a large amount present. Part 2 was exposed to the air in a test tube and in six hours it had formed a "tree" of bulky alumina above the amalgam. This tree was of the same diameter as the button of amalgam, an inch and one-fourth long, and free from the tube on all sides. It was light gray, fairly coherent and showed to a remarkable extent the unstable character of the amalgam. The remaining mercury in part 2 was then tested for aluminium and showed only a trace of that metal. This amalgam was not used on account of its unstable nature.

10. **Magnesium Amalgam.** This amalgam is easily prepared by shaking the powdered magnesium in very hot mercury in a test tube. The amalgam is of a bright, silvery color. It was very unstable and on cooling decomposed rapidly, yielding a black powder (probably magnesium oxide) and mercury. It was not possible to get enough magnesium to combine to produce a solid amalgam on cooling in a closed tube. This amalgam was not used on account of its unstable nature.

#### Preparation of the Ore

The ore used was a quartz carrying free gold from the Anaconda claim, Ten Mile Camp, Idaho County, Idaho.

<sup>8</sup>Schnabel. Handbook of Metallurgy. Vol. II, p. 254.

A 50 lb. lot was run through small rolls and then through a Braun pulverizer so that all passed through 40 mesh. It was then sampled very carefully by coning and quartering, followed by riffles.

As determined by a large number of check assays, the ore averaged 2.49 oz. gold and 2.7 oz. silver. The silver was not considered in the subsequent work.

#### Design of Apparatus

After considerable experimenting with an apparatus designed to change the direction of pulp flow after every 18 in. of plate length, it became apparent that such a machine was not a success. A second type of apparatus was, therefore, designed, consisting of a straight launder, in two 6-in. x 51-in. sections, with a drop of 2 in. between sections. The bottom of the launder was covered with six 6-in. x 18-in. copper plates, overlapping at the ends in the direction of pulp flow. The launder had a uniform slope of  $1\frac{1}{2}$  in. per foot.

The pulp was fed onto the upper plate from an 8-gal. conical sheet-iron tank, through a  $\frac{1}{2}$ -in. valve. On account of the narrow plates used no spreader was found necessary to secure an even layer of pulp over the plates. The pulp, after passing the plates, flowed into a tailing tank of a capacity of 5 gal.

#### Preparation of the Plates

The plates were amalgamated as recommended by Richards.<sup>9</sup> They were rubbed with fine sand with a block of wood until the plates had a uniform red surface, dried and polished. A mixture of 10 sand to 1 ammonium chloride was then made, slightly dampened, and mercury was sprinkled into it. This mixture was rubbed into the plates until they had a uniform, mirror-like surface. They were then allowed to stand several hours and the green stains which developed scoured off and re-amalgamated. The plates were again allowed to stand and the foregoing process repeated until a resistant coat of mercury was obtained.

The plates covered with the different amalgams were prepared as follows: The plates were cleaned and amalgamated with pure mercury. The amalgam to be used was then diluted with mercury until it reached a thin pasty condition, and painted on the surface of the plates in a thin coat. All six plates were given an even coating, no attempt being made to give the top plate any different treatment from the others. When necessary the plates were scrubbed until the amalgam was of uniform texture.

After the runs with each amalgam the plates were cleaned up by first scraping with a piece of belting nailed to a small wooden block and lastly by scraping with a smooth piece of rubber stretched over a metal straight-edge. They were then scrubbed with sand and amalgamated for the next run. The gold amalgam was run last to avoid the possibility of salting the tailing from any other run.

#### Method of Operating

In order that all the tests might represent the same conditions, it was necessary to decide upon a standard method of procedure for use throughout the experiment.

The thickness of pulp which gave the best results was found to be 8 lb. of water per pound of ore, and this dilution was closely followed in all the tests. The pulp was stirred by hand in the tank until it reached a nearly uniform thickness; the valve opened and stirring continued while the pulp flowed over the plates.

The number of times that it was necessary to run the ore over the plates to secure a good extraction was

<sup>9</sup>Richards. Textbook on Ore Dressing. p. 114.



determined experimentally with pure mercury and with lead amalgam. These were run ten times with assays as shown in Table No. 1.

TABLE No. 1									
	1st Run	3rd Run	5th Run	7th Run	10th Run				
Mercury	2.58	2.64	0.60	0.60	0.56	0.56	0.56	0.60	0.56
Lead Amalgam	2.56	1.82	0.80	0.80	0.80	0.78	0.80	0.76	0.82

From Table No. 1 it appears that no further extraction resulted after the fifth run and the remaining tests were therefore passed over the plates five times.

Samples were taken by allowing the entire stream to flow into the sample bucket for a number of short intervals, uniformly spaced through the run. Samples were taken during the first, third and fifth runs, but since it soon appeared that there was little extraction in the first run samples were discontinued. The tests in the presence of impurities were run in the same way with the addition of 5 per cent of the injurious substance to the ore before adding the water.

The standard conditions used may, therefore, be briefly stated: 1. *Dilution*—8 lb. water to 1 lb. ore; 2. *Agitation*—by hand to a uniform thickness; 3. *Number of times over the plates*—five; 4. *Samples*—lip samples during the first, third and fifth runs; 5. *Impurities*—Five per cent added to the dry ore.

#### Description of the Tests

1. **Pure Mercury.** Five tests were run with plain mercury, two on pure ore, and one each with admixture of 5 per cent zinc sulphate, manganese sulphate and ferrous sulphate. All conformed to the standard conditions laid down. Of the two tests on plain mercury with pure ore, one was made at the beginning of the series and one at the end, and these gave closely concordant results. With the addition of the sulphates the plates coated badly, which without doubt accounts for the marked lowering of the extraction under these conditions.

2. **Sodium Amalgam.** The amalgamated plates were painted with 1 per cent sodium amalgam, which gave an exceedingly clean surface, and also by the slow evolution of hydrogen and formation of free alkali kept the plates free from coatings with pure ore.

However, under the influence of the sulphates there was still much tendency to coat. Four tests were run with this and with all the subsequent amalgams: one of pure ore and one with the addition of each of the three sulphates, in the order of zinc sulphate, manganese sulphate and lastly, ferrous sulphate.

3. **Tin Amalgam.** Tin amalgam formed a very bright, clean surface when painted on the amalgamated plates, and proved very resistant to coating by the sulphates.

4. **Lead Amalgam.** The lead amalgam formed a rough, somewhat gritty surface, with dirty, black spots on it that were very difficult to scrub off. However, it was scarcely tarnished at all by any of the sulphates, proving more resistant than any other amalgam tried. It seems possible that the slightly gritty surface aids in catching the gold particles and that this may explain the extraction obtained with the pure ore, which is higher than several amalgams giving an apparently better surface.

5. **Zinc Amalgam.** This amalgam formed a fairly good surface on the plates, but the extractions obtained were very poor throughout. It coated badly under the influence of the sulphates.

6. **Cadmium Amalgam.** The cadmium amalgam gave one of the best of appearing surfaces of any tried and remained quite clean and bright throughout the tests with the sulphates. Nevertheless, it gave one of the poorest sets of results of any in the series for reasons not at present apparent.

7. **Silver Amalgam.** This amalgam gave a good surface, but coated considerably with the sulphates. It was applied in the proportions recommended by Richards' by painting on after the plates were amalgamated with plain mercury.

8. **Gold Amalgam.** The gold amalgam of the consistency of thin paste was painted onto the plate in a similar manner to that used for the silver amalgam. It furnished a slightly gritty surface which showed a tendency to tarnish under the influence of the sulphates. The results were very disappointing, but the rise in the assay of the tailing with each successive run (see the tables) would seem to indicate the probability of salting from the gold used. If the assays of the first run (0.76 and 0.72) be taken, the extraction is as good as was obtained by sodium amalgam.

A total of 4.121 grams of gold were used and 1.699 were recovered on cleaning up the plates. The loss from gold remaining on the plates and carried off by the pulp stream was thus 58.9 per cent.

#### Tabulated Results

The results obtained by the assays of the tailings are recorded in ounces per ton in the following tables, the assays being in duplicate. The assay of the original ore was 2.49 oz. gold per ton.

TABLE No. 2 Ore with Addition of No Impurities							Extraction, Per Cent
	1st Run	3rd Run	5th Run				
Amalgam							
Plain Hg.	2.58	3.64	0.60	0.60	0.56	0.56	77.5
Plain Hg.					0.64	0.56	76.3
Na Amal.	3.30	3.30	1.46	0.72	0.72	0.76	70.2
Sn Amal.	1.46	1.58	1.60		1.08	1.10	56.3
Pb Amal.	2.56	1.82	0.80	0.80	0.80	0.78	68.7
Zn Amal.	1.16	1.08	1.02	1.02	1.10	1.12	55.4
Cd Amal.	1.14	1.14	1.36	1.50	1.48	1.36	43.0
Ag Amal.	1.22	1.22	1.16	1.12	0.96	0.84	63.9
Au Amal.	0.76	0.72	1.16	0.92	1.68	1.68	32.4

TABLE No. 3 Ore with 5 Per Cent of Zinc Sulphate							Extraction, Per Cent
	3rd Run	5th Run					
Amalgam							
Plain Hg.	1.18	1.16	1.08	1.16			55.2
Na Amal.	0.84	0.82	1.46	1.44			41.8
Sn Amal.	0.92	0.92	1.02	0.84			62.9
Pb Amal.	1.12	1.14	1.12	1.10			55.4
Zn Amal.	2.00	1.76	1.78	1.82			27.7
Cd Amal.	1.10	1.12	1.46	1.48			41.0
Ag Amal.	0.98	1.38	1.12	1.12			55.2
Au Amal.	1.58	1.60	1.76	1.84			27.7

TABLE No. 4 Ore with 5 Per Cent of Manganese Sulphate							Extraction, Per Cent
	3rd Run	5th Run					
Amalgam							
Plain Hg.	0.76	0.76	1.40	1.44			43.0
Na Amal.	1.54	1.52	1.04	1.38			51.4
Sn Amal.	1.06	1.06	0.88	1.02			61.9
Pb Amal.	1.04	1.36	0.98	1.04			59.5
Zn Amal.	1.16	1.00	1.18	1.16			52.6
Cd Amal.	1.20	1.20	1.50	1.44			40.8
Ag Amal.	1.02	1.26	1.38	1.44			43.4
Au Amal.			1.22	1.26			50.4

TABLE No. 5 Ore with 5 Per Cent Ferrous Sulphate							Extraction, Per Cent
	3rd Run	5th Run					
Amalgam							
Plain Hg.	1.46	1.46	1.30	1.52			43.4
Na Amal.	1.98	1.96	1.12	1.12			52.2
Sn Amal.	1.12	1.14	1.00	0.82			63.6
Pb Amal.	1.80	1.72	0.86	0.84			65.9
Zn Amal.	1.82	1.80	1.34	1.44			44.3
Cd Amal.	1.66	1.28	1.18	1.18			52.6
Ag Amal.	1.40	2.04	1.18	1.18			52.6
Au Amal.			1.04	1.08			57.4

In order to compare the extraction made by the various amalgams, the percentages are tabulated in Table No. 6, placed in order of the efficiency of the amalgam with pure ore.

TABLE No. 6				
Amalgam	Pure Ore	Ore & ZnSO <sub>4</sub>	Ore & MnSO <sub>4</sub>	Ore & FeSO <sub>4</sub>
Plain Hg.	76.9	55.2	43.0	43.4
Na Amal.	70.2	41.8	51.4	55.2
Pb Amal.	68.2	55.4	59.5	65.9
Ag Amal.	63.9	55.2	43.4	52.6
Sn Amal.	56.3	62.9	61.9	63.6
Zn Amal.	55.4	27.7	52.6	44.3
Cd Amal.	43.0	41.0	40.9	52.6
Au Amal.	32.4	27.7	50.4	57.4

When the average extraction under all conditions is considered, the amalgams are placed as in Table No.

7. These figures are obtained by taking the average of the extractions obtained with a given amalgam when used with pure ore and in the presence of the three sulphates.

TABLE No. 7.

Amalgam.	Average Under All Conditions	Pure Ore	Ore and ZnSO <sub>4</sub>	Ore and MnSO <sub>4</sub>	Ore and FeSO <sub>4</sub>
Pb Amal.	62.2	68.2	55.4	59.5	65.9
Sn Amal.	61.2	56.3	62.9	61.9	63.6
Plain Hg.	54.6	76.9	55.2	43.0	43.4
Na Amal.	54.6	70.2	41.8	51.4	55.2
Ag Amal.	53.8	63.9	55.2	43.4	52.6
Zn Amal.	45.0	55.4	27.7	52.6	44.3
Cd Amal.	44.3	43.0	41.0	40.9	52.6
Au Amal.	41.9	32.4	27.7	50.4	57.4

To determine which of these interfering elements had the greatest effect in reducing the extraction, the mean of all different amalgams, when used with the same impurity was calculated. The percentage of the extraction compared with that obtained with pure ore was also determined, as set forth in Table No. 8.

TABLE No. 8.

Substance	Average Ext.	Per Cent. of Ext. with Pure Ore
Pure Ore	63.1*	100.0
Ferrous Sulphate	53.2	84.6
Manganese Sulphate	50.4	79.9
Zinc Sulphate	46.8	74.2

\*Gold amalgam values omitted as unreliable.

### Conclusions

The results in Table 7 show that plain mercury excelled any of the amalgams in the treatment of a simple gold ore, when free from impurities. In the presence of sulphates, such as are frequently found in oxidized ores, the extraction was much reduced and plain mercury no longer gave the best results. With 5 per cent of zinc sulphate, plain mercury dropped to fourth place; with manganese sulphate, to seventh place; and with ferrous sulphate, to eighth place. When their average performance under all conditions was considered, lead and tin amalgams gave the best results with plain mercury third.

Table 8 shows the relative effect of the sulphates in lowering the extraction. Ferrous sulphate caused an average drop of 15.4 per cent; manganese sulphate, of 20.1 per cent; zinc sulphate, of 25.8 per cent. The injurious effect is due to the coating of the plates caused by the presence of the sulphates, and in general the amalgams which gave high extractions showed less tendency to coat than the others, as may be seen from the results in Table 7.

From the foregoing considerations, it appears that mercury has a greater affinity for gold when pure than when any other metal is amalgamated with it. In these cases where an amalgam shows a higher extraction than mercury alone, the effect is not caused by any increased efficiency due to the presence of the foreign metal; but rather to the superior resistance of the amalgam to the effects of impurities.

In ability to remain bright and clean in the presence of sulphates we have confirmed Aaron's results so far as cadmium-amalgam is concerned, this heading the list; the other amalgams follow about in the order named: Lead, tin, gold, silver, sodium and zinc. Plain mercury was coated worst of all.

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An alloy of silver and cadmium is patented by Edward D. Gleason, of Flatbush, N. Y. It is characteristic of sterling silver, being ductile, durable, brilliant and resistant to oxidation. The composition is about 55 per cent silver and 45 per cent cadmium.

\*Gold amalgam should probably be excepted from this statement owing to the unsatisfactory nature of the results obtained with it.

## Metallurgical and Chemical Engineering in Great Britain

(From Our London Correspondent)

### The General Situation

So far as scientific progress is concerned we are marking time. We do not feel any shame that the general level of papers read this winter before our technical and scientific societies is so poor. One cannot say with confidence that even the Iron and Steel Institute may not fall short of their past high standard in their meetings next month.

The blast furnace, steel foundry and the rolling mill have in one sense never been busier, but it is a business conducted by reduced staffs working at high pressure. Under these conditions the writing of papers becomes a burden which even the keenest are glad to leave aside. There is only the professional element—and that is reduced numbers now left to write papers.

When the war is over we shall pick up the pace again and research will appeal with a new zest. But just now, spare time, thought and talk is given to considerations of what will have to be done when the war is over, with reference to the organization of over-sea trade. Many little informal conferences have been held. Civilian manufacturers and ex-manufacturers in khaki, who have been able to leave their regiments for a few hours have fore-gathered. Difficulties have been frankly recognized, and on the whole the feeling may be described as one of cautious optimism.

### The Sheffield Exhibition of German Cutlery

Your correspondent makes no apology for quoting in extenso the following two paragraphs from the Times Engineering Supplement of February 26, which he had overlooked in his last letter. They illustrate in regard for one industry alone some of the difficulties the recognition of which was mentioned above.

"The opportunities offered by the elimination of Germany's rivalry in the cutlery trade have been very effectively brought home to Sheffield manufacturers by the exhibition of a remarkable collection of German cutlery. The exhibition has been arranged by the Cutler's Company in co-operation with Mr. Walter Tyzack, head of one of the principal cutlery firms in Sheffield, who lent a collection from English agents who have been selling German products to export merchant houses and to retailers. The prices at which these goods had been sold are such as to show how formidable a task it will be for Sheffield manufacturers to secure the two million pounds worth of trade in cutlery which Germany has sacrificed by the war. There were pocket knives at 7½d. a dozen, large two-bladed penknives at 3d. and 4d. each, champagne knives at 2s. 6. and 3s. 6d. a dozen, table knives at 1s. 5d. a dozen, safety razors from 3d. each, folding scissors at 1s. 7d. a dozen, and ordinary scissors at from 1s. a dozen. In many cases the prices of the finished articles are less than the bare cost of grinding in Sheffield, and the bulk of the specimens shown had been sold at about one-third or fourth the average price asked for Sheffield products of similar class. In quality and appearance the German goods were by no means to be despised; the workmanship was good and there was evidence of a strongly developed artistic instinct.

"To enable Sheffield makers to compete with such products some changes in methods, plant and working conditions of a revolutionary character would have to be made. Sheffield cutlers in the past have



by no means been so sympathetic towards the introduction of labor-saving machinery as were the Solingen operatives; but of late a much more reasonable spirit has prevailed and the exhibition—which was visited by crowds far in excess of the accommodation available—will serve to bring home to the workmen a better appreciation of the difficulties with which employers have had to contend in maintaining their businesses."

#### The War and the French Iron and Steel Industries

Although the invaded districts in France at present in German occupation is only 3.7 per cent of the area of France, it is largely industrial, containing before the war 8.2 per cent of the population. Prominent among the industries of the occupied area are those of iron and steel. The following percentages of the total French works are in the enemy's hands:

Iron pipe works	100	per cent
Iron mines	90	"
Pig iron	85.7	"
Iron girders	88.3	"
Coke	78.3	"
Cast steel	76.9	"
Steel rails	76.6	"
Steel ingots	76.0	"
Puddled steel	62.4	"
Iron plates	63.2	"
Iron wire	52.2	"

If in the progress of further conflict much injury is done to these districts France will be badly injured industrially.

The economic outlook in northern France and in Flanders is gloomy in the extreme.

#### Electric Steel-Making Furnace

The April issue of the Journal of the Institution of Electrical Engineers contains a paper read by Mr. T. D. Robertson before the Manchester local section of the I. E. E. with the above title. In its scope the paper was mainly historical and dealt with elementary principles of the Kjellin, Stassano, Heroult and Girod furnaces. The rest of the paper was given to a description of the "Electro-Metals" furnace of Grönwall, Lindblad and Stalhane. The description is characterized by an absence of data, unless the following particulars of the energy consumption of this furnace can be called data: "When melting cold scrap, using two slags and refining to a best quality, the approximate energy consumption decreases from 850 kw. hours per ton, in the case of a two-ton furnace to 750 kw. hours per ton in the case of a five-ton furnace. Those taking part in the discussion emphasized the need for figures apparently unaware that various papers read before the Iron and Steel Institute gave figures for other than the Electro-Metals furnace. It was in reply to this that the author gave some typical figures for the Electro-Metals furnace. For a 25 cwt. furnace producing 1406 tons a year about 850 kw. hours are estimated per ton. Taking electrical energy at 1 cent per kw. hour, and allowing for cost of raw material, labor, electrodes, repair and maintenance and raw material, the cost per ton works out at £6 5s. 6d. For a 2-ton furnace, producing 2250 tons per annum, about 800 kw. hours per ton are required.

Calculating on the same basis as before the cost per ton works out at £5 17s. 8d., and the 5-ton furnace producing 4050 tons per annum at 750 kw. hours per ton, works out at £5 11s. 3d. per ton. Management, laboratory and capital charges are not included in these prices.

#### The Institute of Metals

Absence from London at the time prevented your correspondent attending the March meeting of this Institute, and he has been dependant on the technical press for an account of what took place. Professor H. C. H. Carpenter of the Royal School of Mines presided. Perhaps the most interesting papers were those by Professor Huntington on "The Effects of Heat and Work on the Mechanical Properties of Metal," by Mr. S. Whyte on "The Micro-Chemistry of Corrosion," and by Professor A. A. Read and Mr. R. H. Greaves on "The Properties of Some Nickel-Aluminium and Copper-Nickel-Aluminium Alloys." In regard to the last two papers the common interest of corrosion phenomena linked them together, and it is in this connection that your correspondent would remark upon the apparent necessity for a revision and standardization of corrosion tests. While the index afforded by loss of weight through either direct chemical action or through local galvanized action on any test plate cannot be ignored, a better index and one more quickly ascertained is that of the determination of the e.m.f. (measured, of course, by a potentiometer) between the metal under test and those other metals with which it is likely to be used industrially. The electrolyte should always be the liquid with which the metal under test will come into contact.

#### Engineering Training

In the multitude of councillors there may or may not be wisdom, but of a certainty there will be difference of opinion. Over here we have sharply marked schools of thought as to how engineering education should be imparted, and in what proportions and in what sequence theoretical and practical training should be blended. The latest contribution to the consideration of this subject is Mr. A. P. Fleming's paper recently read before the Manchester section of the I. E. E. The author pointed out that "of the various plans of training for technical positions the following are the most common:

- (a) By a trade apprenticeship combined with evening or part-time study. This method is particularly applicable to manufacturing.
- (b) By a short period in works, then a college course, followed by works' apprenticeship. This plan is recommended by the Institution of Civil Engineers.
- (c) By taking a complete college and then a works' course.
- (d) By sandwiching college and works' training in varying periods.
- (e) By taking a complete works' apprenticeship prior to technical training. This is not a satisfactory method for training for technical positions in manufacturing.

Of these plans, a, b and c are most suitable from the manufacturers point of view; but whichever method is adopted it is desirable that the practical training should terminate in the works, since a better opportunity is afforded to the student for obtaining permanent employment with the firm in which he has obtained his training. It is also most important that the entire training be preceded by thoroughly sound general education.

There is a wide diversity of opinion as to how long a period of practical training a technically educated man should have, and what its nature, should be. Some firms adhere to the five-year apprenticeship scheme as applying to all young men, whether they are being trained as workman or for technical positions, but the more modern tendency is to arrange a shortened course for the latter. While long practical experience is excellent it is not the most effective

method of attaining the end in view. Moreover, a man who has had his intelligence developed by a technical college course should be able to acquire practical experience at a much quicker rate than one not so educated. The object is to afford an insight into manufacturing methods and economics, and to acquire a knowledge of how to handle men.

The author describes the methods employed by the British Westinghouse Co. at their works in Manchester in training their apprentices. The apprentice school method of instruction has been adopted. Instruction averaging about 5 hours per week is given during working hours to all "bound" apprentices, numbering about 300, in a school situated in the works. The regular rate of wages is paid during the time spent in study, and all the cost of books and stationery is borne by the firm. The teaching is done by twelve members of the firm's engineering staff, supplemented by lectures from the leading foreman and shop engineers, which deal specially with the trade subjects. The contact between the foreman and the apprentices in the school produces excellent results, and removes the diffidence which many of the apprentices feel in approaching the foreman with their difficulties. Where it is required to illustrate special processes or describe particular apparatus, which cannot readily be done in the school by lantern projection or drawings, practical demonstrations are given in the works.

The most promising of the apprentices are selected for work in the testing departments and drawing office, and in other respects are allowed a wider range of work than that covered by their own trade. Each year about ten apprentices are selected as a result of their school work and shop progress and sent for one whole day each week to the course for engineering apprentices at the Manchester Municipal School of Technology. The cost of tuition, books, etc., is borne by the firm, and no deduction is made from the wages during the time spent at the school. Such youths are marked for advancement in the company's service as suitable opportunities occur.

Through their work in the school the interest of the foreman is aroused, and as a result increased attention is paid by them in the shops to the practical training of the apprentices.

This apprentice school has only been in operation for about a year, but so far the results both from the point of the company or of the apprentices are most encouraging.

It is early as yet to claim the method and routine employed by the British Westinghouse Co. as a final solution of the problem. For one thing under changing industrial, social and economic conditions there is no finality. Yet the problem before us is an insistent one. The old pride of handiwork and craftsmanship is disappearing, indeed has almost disappeared before the machine too and the factory system.

The pace at which industrial change takes place prevents our ever getting back to the old system and its intense pride of work. Yet some substitute must come. Not only do we do need it for the sake of those who rise by sheer force of character from the ranks, but it is obvious that the daily toil for daily bread of the bulk of our populations should have its intelligent interests and not lead to a mental atrophy of all brain power.

#### Electrolytic Corrosion of Gas and Water Mains

On the 23rd of February a paper was read before the Institution of Civil Engineers on "The Electrolytic Action of Return in Electric Tramways on Gas

and Water Mains, and the Best Means of Providing Against Electrical Disturbances," by Mr. H. E. Yerbury. The author reviewed and criticised the Board of Trade Rules and Regulations and their revisions, from 1894 to the present date, and dealt with the influence of a leakage current on reinforced concrete. The preventive measures proposed by British and Continental authorities in order to reduce the potential differences between tramway tracks and pipes were classified, and a description of the function of a negative booster was given in detail. The author stated that where the rails and mass of earth were positive to pipes in the vicinity of the track there could be no danger to pipes in that area, as they were cathodic. On the other hand, danger existed to all pipes and metallic structures (where imbedded in soil) which were positive to the rails, as it was the flow of current out of the pipes that had a tendency to cause corrosion and pitting. The danger, however, was nothing like as great as would appear from a theoretical standpoint.

He pointed out that as current density and duration of current were the most important factors in connection with injurious electrolytic action on gas or water pipes, potential readings were misleading; it was well known that where a comparatively high difference of potential existed there was, as a rule, less injurious current passing. In his opinion the Board of Trade regulations in respect of leakage currents could easily be complied with on all tramway undertakings, and were absolutely effective in safeguarding the property of other authorities. Up to 600 volts could be allowed between overhead conductors and earth, and this increase of voltage would reduce the cost of feeders and also the heavy currents now dealt with.

#### Market Prices

(APRIL, 1915)

Copper opened £69.10 and appreciated to the 12th, £72.12.6, then fell off slightly to £71.17.6 (13th), but recovered and continued rising to £76.12.6 (19th); was lower on the 20th (£75.17.6), but recovered to £77.12.6 on the 21st and was up to £81.5.0 on the 27th.

Tin opened £168, and was lower £166.10.0 on the 6th, recovering to £170.0.0 by the 8th. On the 9th it had eased to £168.10.0, but recovered and was £171 on the 13th. It then fell away to £164.10.0 on the 16th. On the 19th it had risen to £167.15, but was lower after to £164.10 on the 21st and the same price on the 27th.

Hematite opened 95/- and remained at this price throughout the month.

Scotch pig opened 73/9, and was 75/4½ on the 6th, then declining to 73/3 on the 8th. It recovered to 74/9 on the 12th, but was again down to 73/- on the 13th. Recovered a little 14th and 15th, but afterwards declined and was 70/6 on the 21st.

Cleveland opened 67/9 and was much harder on the 6th at 69/4½. It then declined to 67/3 (8th) and recovered to 68/9 (12th). Another falling off brought it to 67/- on the 13th, and after reaching 66/9 on the 16th, it dropped to 64/6 on the 21st, closing at 65½.

	£	s.	d.
Aluminium, ton lots.....	92	0	0
Alum lump, loose, ton.....	8	10	0
Antimony, black sulphide powder, ton.....	70	0	0
Borax, British refined crystal, cwt.....	1	5	0
Copper sulphate, ton.....	29	0	0
Caustic soda, 70 per cent ton.....	10	2	6
Hydrochloric acid, cwt.....	10	4	6
India rubber, Para, fine lb.....	2	2	3
Quicksilver (Spanish) bottle.....	12	7	4
Sal ammoniac, ton.....	49	0	0
Sulphate of ammonia, ton.....	13	12	6
Shellac, cwt.....	3	5	0
Platinum, oz., nominal.....	9	0	0
Zinc sulphite, cwt.....	8	0	0



## Blast-Furnace Plant Auxiliaries and General Arrangement

BY J. E. JOHNSON, JR.

In addition to the apparatus previously described which is required for each furnace there must be a considerable amount of other equipment for the plant as a whole. Of course, it goes without saying that the enormous tonnages involved at modern blast furnaces can only be handled by first-class railroad track and equipment, both of cars and locomotives, and in sufficient amount, and that at practically all plants of any size cranes for handling heavy parts, cleaning up "messes," and doing innumerable kinds of work that was formerly done by hard manual labor, are extensively used. Very frequently they are arranged to operate grab buckets and magnets as well as serving for general utility cranes. These also are standard equipment and do not need to be specially described here.

### The Water Supply System

The water supply system is one absolutely indispensable portion of the equipment which to judge by the location and the design of some plants was forgotten at the time of their construction and put in subsequently as an afterthought.

The modern furnace depends upon water-cooling for its very existence, not from minute to minute, but literally from second to second, since the tuyeres, coolers and cooling plates are exposed to the most intense heat and the severest conditions of scouring by iron and slag, not occasionally, but in many cases continuously, and only a thin surface of the highest possible conductivity cooled by a violent circulation of moderately cool water prevents their instant destruction.

For this purpose water in considerable quantity must be provided. Its quantity varies very greatly with the size of the furnace and the method of cooling adopted. Cooling plates require more than bosh jackets, and, of course, when cooling plates are used above the mantle they add their quota to the total requirements, since a certain minimum velocity must be maintained for each plate, the minimum depending upon the temperature to which the plate is exposed.

For an ordinary five hundred-ton furnace from 1200 to 2000 gallons of water per minute are required for cooling the tuyeres, hearth and bosh. In addition to this the water necessary for boiler feed, and very generally for condensers, must be supplied, and in modern practice great quantities are being used for gas washing also. This amounts to about 4 gals. for primary cleaning for every 100 cu. ft. of gas or about 2000 gals. per minute if all the gas is washed. It should be noted that the furnace cooling water can be and generally is used over for either condenser or gas cleaning. The consequence is that each blast furnace requires a very respectable volume of water, from 3,500,000 to 6,000,000 gallons per day, and a plant of several blast furnaces needs a supply which makes that of many large cities look small in comparison.

Plants have too often been designed with little or no consideration for their location in regard to water supply. There are perhaps more important considerations such as the arrangement of tracks, etc.—but in a number of cases that have fallen within my own experience a location close to the water supply would have been not only as good but better in other respects than the location actually chosen, at some distance from it, with the necessity of long lines of communication and long-distance supervision of the pumping plant, for, of course, in modern practice long suction pipes are rightly not tolerated, and the pumping plant must be close to the water supply and within a moderate distance

above the water level. Moreover, the pumping plant must be able to run and supply water to the furnace irrespective of fluctuations in the height of the supply. These conditions are easy to fulfill if the plant be on the border of a lake or a stream whose level does not greatly fluctuate, but very difficult to meet in some cases where the source of the water supply is a stream with a rise and fall of many feet, such, for instance, as have the Monongahela and Ohio rivers in the Pittsburgh district.

The design of the pumping station must be based on the local conditions and on the size of the plant. Where a very large plant is needed on the banks of such a river it is often desirable, if not necessary, to sink a huge caisson down below low water level from a point high enough above the river level to be out of danger of floods, and run a tunnel of brick or concrete from this out into the river itself. This, of course, requires a cofferdam of some extent for the construction of the tunnel.

The pumps are located at the bottom of the caisson or pit and the flow of water into it is controlled by valves at the inner end of the tunnel so that no matter how high the river may rise the pumps cannot be drowned out.

The screening of the water is done in the pit, no attempt being made to erect screens over the mouth of the tunnel since they would be inaccessible in times of flood.

In other cases a masonry forebay is built at the bank of the river and extending well down below water level its front being entirely open to the river except that it is guarded by screens. These may either be fixed or arranged to be removed for cleaning. The latter, of course, can only be done by having two separate chambers both of which can be entirely cut off alternately, or by having two sets of screens, one in front of the other so that each one alternately can be raised for cleaning. The possible variations of these methods are of course almost infinite, but the question is one of great importance because the water supply of furnaces is more apt to be interrupted by floods than by any other kind of accident whatever. The likelihood of dangerously low water can be foreseen, and the necessary arrangements for an additional supply made in ample time, but when a flood arises, especially in a mountainous country, two or three hours may see a change from placid operation to one of absolute disorganization on account of water supply. This is for the reason that when these violent floods occur they pick up vast quantities of silt, leaves, and sticks, so that the consistency is almost like soup in extreme cases, and this combination can stop up a screen in a short time almost as effectively as could a plasterer, while owing to the location of the screens it is not always possible to clean sufficient of their area to let through the water necessary to the life of the plant.

Several years ago having occasion to provide a water supply for a small furnace near but not on the bank of a mountain river, subject to rises of some twenty or twenty-five feet, I installed a plant designed to meet these conditions which has been very successful in operation, and of which the principle may be useful to others. This plant was described in the April 18, 1914, issue of the *Engineering and Mining Journal*, from which the illustration of Fig. 1 is taken.

A forebay of brick-work was built with its base about two feet below the lowest water level, very much as in ordinary construction, but instead of screening this with a straight stationary screen a circular revolving screen was used, which was supported on trunnions built into the masonry. The outlets for the screened water were through the ends of the screen wheel and





to be out of reach of any possible flood, and in case of a flood the pump cylinders may be submerged and continued to run indefinitely in that condition. These, of course, are necessarily large units and their speed of revolution is limited by the ability of the water to make its way through the valves and follow the plungers which, on account of the inertia of the water, is at a very slow rate. These pumps, therefore, seldom run at more than thirty revolutions, which makes their cost very high in proportion to their output.

In the last ten or twelve years the centrifugal pump with multiple stages has been developed to a high state of efficiency, and instead of being limited to thirty or forty feet lift as was the old single-stage centrifugal pump some twenty years ago, these pumps are now designed for lifts up to many hundred feet. Their efficiencies with good designs range from seventy per cent up to eighty in exceptional cases, and while this is considerably lower than the efficiency of a good plunger pump it is maintained through a long period of years.

The pumps are almost independent of leakage, operating solely by the velocity which their impellers impart to the water, and they are entirely valveless so that under any ordinary circumstances they will run without interruption for very long periods of time.

One word of caution may not be amiss here. The old centrifugal pumps were designed so that they would pass anything up to the size of cabbages, but the modern multiple stage pumps have what may be called a closed impeller with the outlets at its periphery rather narrow, so that sticks of moderately small sizes may lodge in these and cut off the water flow. For this reason screens must be provided with openings small enough to bar anything which could lodge in these discharge ports. The obstructions which will pass these ports are however larger than those which were likely to derange the valves of reciprocating pumps, and centrifugals have therefore the best of the argument in this very important respect. Owing to their extreme simplicity and to the fact that they have but one moving part, and to the entire absence of valves these pumps are relatively inexpensive, a result which is attained by virtue of the fact that they are run at very high speeds, and pass an enormous volume of water in proportion to their size.

I well remember that the master mechanic at the plant at which the pumping plant illustrated above, Fig. 1, was installed, assured me with great respect, but nevertheless with profound conviction, that those pumps would never deliver water enough to supply that furnace. When they were put into operation, however, one of them promptly ran away with the supply brought in by the race from the river, he had to bestir himself to increase the supply, and his doubts were overcome with a vengeance.

Centrifugal pumps on account of their extreme simplicity may be operated practically without supervision or at least only at several hour intervals, there being only a few oil cups to look after. These pumps may be driven by any type of motor desired but for large sizes there are practically only two to be considered. One is the electric motor, the other the steam turbine.

When the pumping plant is located at some distance from the main plant, electrical transmission is to be desired, as it will run for many hours without attention if properly installed and equipped, so that an occasional visit of an attendant is sufficient, whereas when steam machinery is employed it is virtually necessary to have an attendant on duty all the time though his work may be of the lightest 95 per cent of the time.

In small sizes the electric motor driven from an economical central station is probably more economical than

the turbine, because the turbine economical in small sizes has not yet been developed, but in large sizes the directly connected turbine furnishes an ideal drive for these pumps. On account of the very high efficiency of the turbine, especially in view of the fact that a surface condenser may be installed in the water main and a very high vacuum attained without much expense, it is probable that the best type of unit of this kind is as economical in steam consumption as the vertical pumping engine earlier described because the greater efficiency of the turbine offsets the smaller efficiency of the pump, and the cost is only a fraction of that of the engine driven unit, so that where steam-driven plants are to be installed it may be expected that the turbine-driven centrifugal pump will play an increasingly important part.

In one plant of which I formerly had charge the pumping plant consisted of triplex plunger pumps belt driven from electric motors, and while the pumps were poorly designed and were too weak for the service for which they were furnished the combination formed (with this exception) a very satisfactory plant, and to my surprise the efficiency of the pumps was very high. A test was made of one of them using a large and accurate weir to measure the water, and although the pump was not tuned up for a test, but tested in its ordinary running condition, the efficiency of pump and motor figured out about 85 per cent, and undoubtedly a plant of triplex pumps properly designed and geared to their driving motors would be an effective and satisfactory type of pumping plant where electric drive was desirable, but of course this type of machine does not lend itself to satisfactory steam drive.

The details of these different types of pumping plants are no different from what they are in ordinary service and therefore need not be especially described and illustrated here.

### Stand Pipes

The water supply is vital to the life of the furnace plant and must be continuous, since the failure of the water supply on the tuyeres for two seconds would almost certainly cause them to be burnt, and only a few seconds more would be necessary to burn the coolers and cooling plates as well. For this reason no amount of care expended to secure a reliable and constant water supply to the furnace is too great.

It is obvious that even with duplicate units in the pumping plant there must be an interruption of a few minutes from time to time in the supply, and it is therefore universal in good modern practice to have a stand-pipe with a capacity sufficient to take care of the furnace water supply for a limited period. What this period should be depends upon the judgment or, one might almost say, the individual caprice of the designer of the plant. I have seen some plants at which the stand-pipe looked hardly bigger than the smoke pipe of a domestic stove, while at many others it is of the size that would do credit to a large city.

It is probable that the stand-pipe should be sufficient to maintain a full supply of cooling water on all the furnaces for at least one hour. Then in case of a serious failure of the pumping plant the furnaces would be shut down and the water supply slacked to a very small percentage of its normal flow, and in this way they would be saved from injury for several hours. In case of necessity the tuyeres and even the coolers can be pulled if it is obvious that the water supply can not be restored before the stand-pipe gives out.

There are three types of stand-pipe in common use: first, the straight cylindrical pipe like a stack, second, the elevated tank (generally in modern practice having a spherical or parabolic bottom) supported on a steel

tower, and third, a flat tank of relatively small depth placed on top of some building for which it acts as a roof.

The first type is the poorest for the reason that only the upper third of it is useful for storage since when the water falls below that level the head is insufficient to maintain a proper supply. Or if the tank is built so high that a greater proportion is available then the water must be pumped much higher than is necessary to obtain the desired amount of storage, with consequent waste of power and high cost of equipment.

The second type is that which is commonly used as the stand-pipe for cities if no hills are available, and for large plants. The tank is elevated to such a level that its whole contents are available for a water supply, and the excess of the maximum over its minimum height of the water level in it is small so that not much excess pumping is required.

The third type is not so common now as it was a few years ago, but has much to recommend it, embodying as it does a very large storage with a very small fluctuation in height, and being supported on the walls of the building whose roof it forms, its expense is not excessive, although of course very heavy girders are required across the building to sustain its weight.

At some fortunate plants which receive their water supply by gravity little or no tank is used because of the slight probability of interruption to the regular water supply there being no machinery to fail.

#### Water Mains

The character of the water main, like that of many of the other auxiliaries, is determined primarily by the size of the plant. For small plants nothing but cast iron pipe is probably ever considered, but for larger plants riveted steel mains have sometimes been used, and it is possible that in the larger sizes they are cheaper for a given strength. One point should, however, always be kept in mind in designing mains, and that is that the water which is pumped through them varies from just above the freezing point to eighty or ninety degrees in some districts. The expansion therefore is considerable and means must be provided to take care of it. At one large furnace plant a large riveted steel main was pulled in two by contraction after being several years in service, and the job of making even a temporary repair was a very difficult one, while it could not be permanently repaired except by having the whole plant shut down, a condition which should not exist for many years at a stretch.

This illustrates a point which it is well to bear in mind in connection with auxiliaries, that while each furnace and its immediate accessories are shut down completely at periods ranging from one to three or four years the plant as a whole, even though it be not a very large one, is not likely to be shut down so completely as to permit stopping the auxiliaries for many years at a stretch. This fact should be borne in mind in laying out water mains, gas mains, electric lines, and sewer systems, particularly the first and last on account of their great size, their being buried underground, the great expense of doing anything with them, and the vast difficulty of rigging up temporaries to permit repairs to the regular ones.

Returning to the matter of the kind of pipe to be preferred, the cast iron has two very great advantages. The first is that cast iron is less subject to corrosive influences than any of the other ferrous metals, the extent to which it is eaten away being only a fraction of that at which steel is attacked under the same condition.

Second: A bell and socket cast iron pipe is laid with a lead joint every twelve feet, this lead being cast and calked to place on a backing of oakum in a way that

makes it virtually an expansion joint, so that the expansion of each section is taken up at its ends. No heavy contraction stresses can arise in this kind of pipe, nor can any distortion due to cumulative expansion from one end.

Steel pipe, on the other hand, is rigidly fastened together in one piece, and if special precautions be not taken to prevent, the expansion or contraction is liable to be concentrated at one point and cause the failure of the pipe at that point. For this reason if steel pipe be used as a main water supply system, well-made expansion joints, preferably made on the principle of a huge stuffing box filled with oakum, hemp or other packing, and set up with a gland, should be inserted at such distances as to localize and limit the expansion and prevent its doing damage.

Where large plants are concerned, it is a matter for very serious consideration whether two mains should not be used instead of one, the two together being large enough to supply the whole plant, and one of them able to furnish an emergency or partial shut-down supply. By the introduction of a comparatively small number of duplicate valves permitting both mains to supply all parts of the plant, and at the same time enabling large sections of either to be cut out, provision can be made for repairs to these important accessories without much difficulty or expense, something virtually impossible when a single main is used.

#### Furnace Main Connections

The connections from the water main to the circulating system around the furnace are a matter of the greatest importance, and no amount of care, and no reasonable amount of money is too great to secure freedom from failure here.

It has been my misfortune to experience three partial failures of this kind, and while in every case we escaped without serious damage to the furnace, we were forced to desperate expedients, in one case being compelled to pull the tuyeres from the furnace as the emergency supply was insufficient to supply these as well as the coolers and cooling plates, the latter could not be removed without serious delay and so were left in and fed with the minimum quantity of water which would prevent boiling. In this way we managed to prevent the burning of any cooling member while we changed the fitting in the main supply line which had split but still remained in place, although its duration was evidently to be measured by minutes rather than hours.

It is my judgment that two independent supply lines should be used, equipped with the modern type of non-return valves close to the furnace main, these valves being bronze fitted throughout so as to prevent sticking in the hour of need. These supply lines should be of moderate size so that normally some water would flow through each and keep them both active, while in case of trouble with one the other would deliver an emergency supply. The non-return valves in case of breakage would prevent the water delivered by the unbroken main from flowing back out through the one which failed and is an indispensable feature of such a design.

#### Waste Water System

Until within recent years all the water used by the furnace was returned to the sewer supply so little polluted that it required no special treatment, the water having been used almost exclusively for cooling and condensing purposes, but this is no longer true since the introduction of the gas washer. The wet scrubbing of gas requires a large quantity of water both for cooling and cleaning purposes, and the water discharged from these systems is exceedingly foul, containing the dust from the gas, and also much of the fume which we



have been accustomed to consider separate from the dust. In most cases to return this foul water by way of the sewer system to the source of supply would be to invite legal action, and it must accordingly be settled so as to remove the greater proportion of its suspended matter. Even after giving it careful settlement it is still quite foul and should not be turned into the main sewer system without careful examination to see that it will not cause the filling up of the latter either by precipitation of suspended material, or by the formation of a deposit of dissolved matter upon the sewer walls.

Where very large quantities of waste water are to be handled brick or concrete sewers are used practically the same as in regular city sewer work, but the branches from these or the main sewer at smaller plants may be of different material. Generally terra cotta pipe is used from about two feet in diameter down, but in many cases square wooden boxes of heavy plank, strongly spiked together, are used very satisfactorily since they are relatively inexpensive and are very durable if located so that they stay wet all the time and are not liable to be broken by light shocks and heat, as are terra cotta sewers. It is probably safe to say that in nine cases out of ten the sewer system does not receive as much attention in the designing of plants as it probably should, and is put in as an afterthought, with the result of costing more, and not improbably being worse located than it might have been had it received earlier consideration. Above all, consideration should be given to design small sewers so they can be cleaned by punching without digging them up.

In many cases also where terra-cotta is used for secondary permanent sewers it is probable that the greater strength and durability of cast iron pipe of light section would more than justify its increased cost, since difficulties with a sewer, while they are not very frequent, are inconvenient and expensive to the last degree. Some miserable sewer buried under the ground and never thought of once a year, whose failure to carry off the waste water results in flooding everything, may necessitate the shutting down of the plant for hours in order to cut off or reduce the flow of water.

One point in the design of the sewer system relative to the plant as a whole is worthy of note. In plants located in northern climates much trouble is sometimes experienced from anchor ice forming on the screen below the water level and shutting off the supply of water. The main waste sewer is normally located to discharge below the pump intake, as is absolutely right and proper, but where this discharge consists of practically clean water which has been used only for cooling purposes the sewer may well be provided with an auxiliary discharge just above the main intake screen of the pumping plant, whereby some of the warm water returning may be discharged at the river bank so as to warm the entering water a little above the freezing point and so serve to cut off or prevent the formation of anchor ice with all its attendant annoyances. These are minor points in the consideration of the blast furnace plant as a whole, but they are apt to be extremely expensive ones unless given careful thought in advance.

#### Compressed Air Supply

In former times before electricity had reached its present state of development a supply of compressed air was one of the greatest conveniences that could be installed at a furnace plant. It was very frequently used for operating bell cylinders, for drilling the tapping hole, for operating pneumatic tools on repair jobs, and many similar operations. For this purpose an air compressor of good design was installed in the power plant, and the air piped to the points of utilization. In good

practice branches with valves were inserted in the main at different points so that air could be taken wherever it might be needed, with a short temporary line or hose.

The modern designs of air compressors are greatly improved over those of a few years ago, being more economical and more reliable, and air supplies a very desirable form of power, being absolutely safe and extremely convenient. Especially for repair and construction work no substitute for the compressed air riveter and other tools of that kind has as yet been discovered. Where compressed air plants are installed as a permanency an after cooler should always be provided to cool the air to or below the temperature of the atmosphere just outside the power house so that the moisture condensed out of the air by compression may be removed at that point and not go through the line as vapor to condense in some distant pocket where it can make trouble in Winter by freezing up.

Many types of compressors have been brought out, and one known as the straight line type, which is of the same general design as the long cross head blowing engine, but laid horizontally, has had considerable popularity, but compressors are very uneconomical unless they are compounded as to both steam and air. This means two cylinders for each, and therefore the straight line type must have four cylinders all in a line to embody these features. This makes a rather complicated and extremely inaccessible type of apparatus, and as this type of engine has two cranks and two connecting rods virtually no more machinery is involved to make a cross compound, two-stage tandem apparatus of it, with the advantage of vastly greater accessibility and generally a more economical design. The space required, and the foundation cost are greater with the cross compound type, but its operating advantages are well worth the difference.

#### Electric Supply

There are still a few furnace plants in existence which are without an electric supply, and are lit at night by oil torches, colloquially known by the descriptive name of "smoke pots," whose light is extremely poor and inconvenience very great, but within a few years the furnace which does not have an electric plant at least for lighting purposes will be a thing of the past. On practically all modern plants so much of the work is done by electricity that an electric plant of considerable size must be provided. In many cases the electric stock hoist is used, electric bell hoist, pumping plants, lights, and many other minor but necessary operations of the furnace are conducted by electricity.

Where the furnace plant is in conjunction with steel works the electric plant of the combined works becomes enormous. That at a steel works of two or three thousand tons daily capacity is probably as large as that of the average city of half a million people. The electric plant for the blast furnace does not differ essentially from electric plants for other uses and must be designed primarily with reference to its size and the service to be expected of it, never forgetting that on account of its convenience other duties will be hung on to it from time to time, and that the plant which does not start with a hundred per cent reserve capacity will probably soon be too small to do what is required of it.

Where very large electric plants are to be installed it is still a question as to whether the gas engine or the steam turbine is the more economical. The gas engine is undoubtedly the more economical by twenty-five to thirty-three per cent on the heat unit basis, but its operating cost is decidedly higher, and its fixed charges are very much greater than those of the steam turbine. It is therefore very largely a matter of local conditions.

If coal be high, intelligent labor plentiful, and capital not too dear, the gas engine is to be preferred. When these conditions are reversed undoubtedly the steam turbine is the best. The intermediate conditions must be decided on their merits after careful examination of all the factors.

The steam turbine has one great advantage in that it may be used as a low pressure machine exclusively, and in two of the most modern plants which combine both blast furnaces and steel works the blowing engines are steam driven, and exhaust their steam about at atmospheric pressure into turbines which drive the electric generators. The turbine is by far the most economical motor in existence for low pressures, while it is inferior to the piston engine at higher pressures. This arrangement places each type of machine under the conditions for which it is best adapted, and makes a type of plant which has everything to commend it when the electrical requirements are sufficient to use up the steam from the blowing engines.

In smaller sizes the electrical plant may be either steam engine or turbine driven, the steam engine probably being preferable in small sizes and the turbine having an increasing advantage as the size of the plant increases.

#### VOLTAGE AND KIND OF CURRENT TO BE SELECTED

The voltage and kind of current, direct or alternating to be preferred depends on the local conditions. For small plants two hundred and twenty volt direct current gives excellent satisfaction. This voltage is high enough to keep the cost of copper in transmission lines within reason, and is low enough to give good service with incandescent lamps, while for electrical machinery which requires much control, such as cranes, ore bridges, and the like, direct current still seems to have the advantage over the alternating on account of the ease of reversal, the possibilities of dynamic breaking, etc. At large plants where the power is transmitted in great quantities the direct current is out of the question except as an auxiliary. The alternating current must be used so that it may be stepped up to any voltage desired for transmission and stepped down at the point of utilization. If direct current be required for crane service or the like, it is produced by motor generator sets or rotary converters. When alternating current is used different voltages may be used in different services to suit the individual conditions. For mill motors and the like where men are likely to come in close contact with them four hundred and forty volts or less are used, whereas on large motors such as those which drive rolling mills direct, voltages from twenty-two hundred up to sixty-six hundred are used.

*(To be concluded in July issue.)*

Messrs. Eimer & Amend, Eighteenth Street and Third Avenue, New York City, have issued their catalog M on Apparatus for Metallography, describing the Wysor combined grinding and polishing machine and optical metallographic apparatus.

Ulcology is a new copper-lead alloy made by the United Lead Co., 111 Broadway, New York City. While ordinary copper-lead alloy under usual conditions cannot be cast without a crystallization of copper long before the lead hardens, ulcology is made by a patented process in such a way as to hold the copper uniformly distributed throughout the mass until it cools and hardens. The chief applications of ulcology are as a bearing metal, as a metallic packing and for bronzes and castings. As an acid-resisting alloy it is especially suitable for acid valves and pumps where polluted or acid waters come in contact with it.

## The Chemical Industries of Germany<sup>1</sup>

BY PROF. PERCY F. FRANKLAND, F.R.S.

It is remarkable that the Royal House of Prussia has during many centuries been associated in one way or another with chemical enterprises of various kinds. Thus already the second ruler of the country, the Markgraf John (1608-1619) was actually surnamed "the Alchemist" in consequence of the zeal with which during many years he pursued his investigations on the transmutation of metals, whilst a number of his successors exhibited great interest in the same problem—the manufacture of gold—which has never failed to fascinate the needy princes—and what princes are *not* needy?—of all ages and all nations.

The Great Elector (1640-1688), who did so much to advance the power of Prussia, was a patron of chemistry, which was just then beginning to emerge, as an experimental science from the obscurantism of alchemy. He provided the celebrated Kunkel with a laboratory and glass furnaces on an island in his park at Potsdam, and it was there then in 1678 Kunkel made the discovery of ruby glass, produced by means of traces of gold, and which is still an unsurpassed method of coloring glass for ornamental purposes. Kunkel also rediscovered phosphorus, which has previously, in 1669, been obtained by the alchemist Brand of Hamburg, who had quite accidentally produced it in the course of his attempts to extract the Philosopher's Stone out of urine.

But while the discovery of yellow phosphorus is thus of German origin, its production on an industrial scale was, until twenty years ago, only carried on in England and France. In 1892, the manufacture of phosphorus by electrothermic means was introduced into Germany by the Chem. Fab. Griesheim-Elektron at Frankfort.<sup>2</sup> Red phosphorus was discovered by Schrötter, an Austrian chemist, in 1848, and was adapted for safety-matches by the German Böttger in the same year. His invention was first taken up in Sweden, and was not adopted until ten years later in Germany.

The match industry has assumed its largest dimensions in Germany. Thus the German annual production in 1912 was \$23,000,000.<sup>3</sup> The value of all matches (British and foreign) consumed in Great Britain in 1910 is estimated at \$6,468,750—about nine matches per day per head. Messrs. Bryant and May's (by far the largest English concern) turned out 1,152,000,000 boxes in 1907. This represents about one-half the British output. In 1907 the total value of British production was \$3,875,000, of which \$380,000 worth was exported.<sup>4</sup> The British export of matches is diminishing. It is worthy of note that Japan in 1901 exported matches to the value of \$6,000,000.

#### PORCELAIN

Another great German industry owes its origin to alchemistic studies made by Böttcher in the reign following that of the Great Elector, namely, that of Frederick III. (1688-1713), first King of Prussia. Having succeeded in making gold before witnesses, Böttcher was seized by order of the Elector of Saxony and was "interned" at Dresden, where, although he did not succeed in making the much-desired gold, he founded along with the physicist Tschirnhaus, the celebrated Dresden porcelain industry.

The astute Frederick the Great (1740-1786) was

<sup>1</sup>A paper read before the Birmingham section of the Society of Chemical Industry, on March 4, 1915.

<sup>2</sup>The author has much pleasure in acknowledging the assistance he has received from the valuable compilation by Professor Lepsius of Berlin, "Deutschlands Chem. Industrie 1888-1913," and from that by Dr. Duisberg, of Elberfeld, "Wissenschaft und Technik," 1911.

<sup>3</sup>Mollinari, "General and Industrial Inorganic Chemistry," 1912.

<sup>4</sup>Clayton.



anxious to manufacture the Dresden ware at Berlin and to this end commissioned his court apothecary, Johann Heinrich Pott, to institute investigations. These attempts were, however, all unsuccessful.

The great Frederick placed much faith in secret agents and it was by means of spies that he succeeded in discovering the secrets of the Dresden porcelain manufacture, for at his instigation an enterprising merchant, bearing the name of Gotzkowski, with the assistance of a Saxon workman, brought the secrets of the Dresden process to Berlin and established a porcelain factory in the Leipziger Strasse, which still remains the warehouse for the Berlin porcelain goods. But Frederick later stopped the pecuniary assistance with which the factory had been subsidized, and Gotzkowski was forced to sell the concern of Frederick for about \$150,000, and so was established the celebrated Berlin Royal Porcelain Factory, amongst the products of which are the well-known crucibles and evaporating basins. The flourishing state of the German porcelain and pottery manufacture is attested by the fact that during the past twenty-five years the number of works has increased from 228 to 359, and the number of workpeople employed from 37,000 to 66,000. In 1912 the German exports of china, earthen and stoneware were valued at upwards of \$17,500,000.

#### GLASS

Even still more important is Germany's glass manufacture, for which she has long been pre-eminent. The annual export in recent years has been over \$35,000,000.

#### CYANIDE INDUSTRY

In the early eighteenth century an accidental discovery was made by Diesbach, a Berlin color-maker, which has proved of great industrial importance. Diesbach was preparing what is known as Florentine lake, a red pigment obtained by precipitating a solution containing cochineal extract and an iron salt with caustic potash. It so happened, however, that the potash used by Diesbach had been in contact with bone-oil containing some cyanide, and the result was that, instead of the result he anticipated, a magnificent blue coloring matter was obtained. This substance, which is still known as Berlin or Prussian blue, was the first cyanogen compound to be discovered.

The cyanogen compounds have played a most conspicuous part in the development of organic chemistry, and every source of cyanogen has been exploited for obtaining them. In recent years the demand has increased enormously owing to the employment of sodium and potassium cyanides in the extraction of gold. To meet this demand a number of synthetical methods for their preparation have been super-added.

Germany's annual production of cyanides is estimated at 10,000 tons, valued at \$3,250,000, or about half of the world's production.

#### BEET-SUGAR INDUSTRY

Another industry, also had its beginnings in the eighteenth century, during the reign of the Great Frederick, and was the outcome of the laborious researches of Marggraf (born in Berlin in 1700, and a pupil of Stahl) on the occurrence of sugar in the vegetable kingdom. Of the numerous plants investigated from this point of view he found that the beetroot (*Beta vulgaris*) contained the largest proportion of saccharine material and that the sweet-tasting substance was identical with that present in the tropical sugar cane (*Saccharum officinarum*).

It was not, however, until some fifty years later that the observations of Marggraf led to the first beet-sugar

factory in the hands of Franz Karl Achard, who was subsidized in this venture by the Prussian King, Frederick William III (reign 1779-1840), who was also the founder of the University of Berlin.<sup>5</sup>

The beet-sugar industry had to contend with strenuous competition on the part of the cane-sugar manufacturers, who were chiefly English and who are said to have endeavored to corrupt Achard by heavy bribes. The industry was, however, greatly promoted when, in 1806, Napoleon issued his famous edict closing the European ports to British goods. The vast extent of this industry at the present time can be gathered from the following figures:

Total sugar crop for 1912-13: Cane sugar, 9,211,755 tons; beet sugar, European (one-third German), 8,310,000 tons; beet sugar, United States, 624,064 tons; total, 18,145,819 tons.

The sugar industry should give us food for serious reflection when we consider the following facts: United Kingdom spends annually \$115,000,000 on 1,700,000 tons imported sugar. Germany produces \$180,000,000 worth of beet sugar on 1,300,000 acres. France produces \$65,000,000 on 570,000 acres; all continental countries together produce \$580,000,000 on 6,000,000 acres.<sup>6</sup> In the United Kingdom there is only one small experimental beet-sugar factory in existence. The beet-sugar industry is of particular interest in connection with the present European crisis, inasmuch as it is a most notable example of an industry which largely owes its successful inception to a state of war which disturbed the previously established order of things in the matter of sugar supply.

In this country [Great Britain] agriculture is well known to be productive of a conservative frame of mind, but that it is not so in Germany is well illustrated by the extraordinary progress which has been made in the cultivation of the sugar beet under the guidance of systematic scientific research. Thus, in 1840, 100 kilograms of beet gave 5.9 kilograms of sugar; in 1850, 7.3; in 1870, 8.4; in 1890, 12.5, and in 1910, 15.8. In 1871 the mean production of beet per hectare<sup>7</sup> was 246 quintals,<sup>8</sup> and in 1910, 300 quintals. In 1867 the consumption of coal for 100 kilograms of beet was 35 kilograms; in 1877, 24; in 1890, 10, and in 1900, 7. Further economy in coal has been effected by means of the Kestner concentrator.<sup>9</sup>

#### SULPHURIC ACID, SODA AND BLEACHING POWDER INDUSTRIES

Sulphuric acid was discovered by the German alchemist Basil Valentine in the fifteenth century. The production of this fundamental acid, however, on any considerable scale took its origin in Birmingham, where Dr. Roebuck in 1746 introduced the classical leaden chamber process. At the beginning of the nineteenth century it became an industry of great importance, more especially in England, because of this acid being required for the manufacture of carbonate of soda by the Le Blanc process.

The manufacture of Le Blanc soda was taken up in England in 1814, especially in connection with soap-making, and it was in England that this manufacture assumed the largest proportions. The enormous ad-

<sup>5</sup>There was no University in Berlin until 1809, but the following figures will show how Prussia has made up for lost time in this respect. In 1913-14, there were 7613 male and 770 female matriculated students, and 4113 male and 89 female non-matriculated students. The annual income was \$1,231,550, of which \$1,023,250 came from the State, \$204,500 from fees, etc., and \$3,800 from other sources. The annual expenditure was \$1,231,550, of which the teaching staff accounted for \$523,950; departmental expenses, \$500,700; building expenses, \$53,050; reserve, \$33,400; administration, bursaries, etc., \$120,450. ("Minerva," 1914.)

<sup>6</sup>C. W. Fielding, "Morning Post," Jan. 23, 1915.

<sup>7</sup>Hectare = 2.5 acres.

<sup>8</sup>Quintal = 100 kilograms.

<sup>9</sup>Molinari, "General and Industrial Org. Chem.," 1913.

vances made in this manufacture during the past century may be gathered from the fact that the price of carbonate of soda in 1818 was about \$210 per ton, while to-day it is only about one-tenth of that amount. One of the determining factors which made England the principal home of soda manufacture was the great development of the English cotton industry during the nineteenth century.

During a large part of the last century England manufactured Le Blanc soda, sulphuric acid and bleaching powder<sup>10</sup> for most of the world. But during the latter half of the century the rival ammonia soda process made its appearance. The original discovery of the reaction on which it depends—it was first patented in England by Dyar and Hemming in 1838—is ascribed to several different persons, but the process was first made an industrial success in Belgium by M. Ernest Solvay. The Couillet works were founded with a capital of about \$30,000 in 1863; the numerous affiliated works are now to be found in Belgium, England (Brunner, Mond and Company), Germany, France, Italy, Spain, Austria-Hungary, Russia and North America. They employ 35,000 persons. During the fifty years the price of soda has been reduced from \$80 to \$20 a ton. The displacement of Le Blanc soda by ammonia-soda involved the introduction of new methods of chlorine manufacture. After numerous abortive attempts in various directions, the successful production of electrolytic chlorine has been achieved, and about half of the bleaching powder in the world is now made by this means.

Electrolytic chlorine is now often converted into liquid chlorine (12 cents a kilogram), of which large quantities are used at Stassfurth for the annual preparation of 500,000 kilograms of bromine, and the Badische Anilin und Soda Fabrik used in 1900 more than 1,000,000 kilograms for the preparation of chloroacetic acid employed in the manufacture of synthetic indigo.

In the manufacture of sulphuric acid, again, the old-fashioned English or leaden chamber process has not been allowed to remain unchallenged, for since the beginning of the present century it has had to meet the competition of the so-called contact process. This is based on a long known reaction,<sup>11</sup> which, however, remained almost unutilized until the meticulous industry of German chemists and the courageous enterprise of German manufacturers developed it into a commercially successful process, which was elaborated in the works of the Badische Anilin und Soda Fabrik at Ludwigshafen.

The ammonia-soda and the contact sulphuric acid<sup>12</sup> processes, although carried out in England, have been largely instrumental in making other countries, more especially Germany and the United States, independently of the English production of these all-important chemicals.

In 1882 the world's consumption of soda was 700,000 tons (160,000 ammonia-soda), and in 1902, 1,760,000 tons (250,000 Le Blanc). In England, in 1876, \$35,000,000 was invested in the industry, which gave employment to 22,000 workpeople. In 1880 the British output was 430,000 tons, and in 1896 it was 800,000 tons. North America in 1886 produced 1100 tons, and 300,000 tons in 1898; and Germany in 1878 made 42,000 tons, 300,000 tons in 1901 and 400,000 tons in 1910.<sup>13</sup> The first soda works in Germany was only erected in 1843 by Hermann at Schönebeck, near Magdeburg, and the first

leaden chamber by Kunheim in 1844 on the Tempelhof Plain near Berlin. (See also the statistics in Table I.)

#### HYDROGEN INDUSTRY

The electrolytic production of soda and chlorine is, of course, attended with the evolution of enormous volumes of hydrogen. At first this gas was allowed to go to waste, but gradually interesting and important uses have been found for it.

1. Dirigible balloons have been rendered possible by taking advantage of the lightness of the internal combustion engine. One horse-power engines are but little heavier than 1 kilogram. Twenty-seven thousand cubic meters of hydrogen is required for a modern airship. The balloon sheds are often established near electrolytic soda works, or the gas may be transported in steel cylinders compressed to 150 atmospheres. Five hundred cylinders containing 2750 cu. m. of gas are placed on one railway wagon and more than eight such wagon loads are required for the filling of a single Zeppelin.

2. Autogenous welding with oxyhydrogen flame, a most important application of hydrogen, was introduced at the beginning of this century by the Chemische Fabrik Griesheim-Elektron. The oxy-acetylene flame is now more commonly used.

3. Artificial gems are made by means of oxy-hydrogen flame. Some thirty years ago C. V. Boys succeeded in fusing quartz with the oxyhydrogen flame and then drawing it out into incredibly thin fibers, which have proved of the highest value for certain physical experiments of extraordinary delicacy. The same source of heat was much later, in the nineties, employed by the French investigator, Michaud, to reconstruct rubies from small fragments of this gem. At the beginning of this century Verneuil and Paquier, in Paris, succeeded in making synthetic rubies. A little later Wild, Miethe and Lehmann in Germany elaborated methods for producing synthetic corundum, rubies, amethysts and sapphires, which are manufactured by the Elektrochemische Werke at Bitterfeld. These products are identical in chemical composition and physical properties with the natural gems, and the rarest varieties of these can be obtained at will. Fused alumina (very pure) gives corundum; fused alumina + 2½ per cent chromic oxide gives ruby; fused alumina + magnesia and titanium oxide and ferric oxide gives blue sapphire. These synthetic gems are now manufactured to the extent of about 6,000,000 carats annually (1 carat = 0.205 gram), or 1230 kilograms or more than 1 ton. Experienced connoisseurs can, however, distinguish between the natural and artificial gems, with the result that the former have not diminished in value. Natural rubies or sapphires of 2-4 carats cost \$100 to \$250, and larger stones up to \$750, while the artificial would only cost 1/500 to 1/1000 of those amounts.

A still more recent and much more important application of hydrogen is for the hardening of fats, which depends on the transformation of unsaturated into saturated acids by means of hydrogen in the presence of a catalyst (nickel, palladium, etc.).

#### INDUSTRIES CONNECTED WITH ARTIFICIAL ILLUMINATION

The world is greatly indebted to Germany for inventions which have largely revolutionized artificial illumination, firstly, in connection with gas and more recently in respect of electric lighting.

Thus, one of the most remarkable discoveries in this domain was that of incandescent gas lighting, which was made by the Austrian Count, Dr. Carl Auer v. Welsbach of Rasternfeld in Styria, as the result of lengthy, laborious and ingenious researches. The now

<sup>10</sup>Discovered by Tennant in 1799.

<sup>11</sup>This reaction had for many years been used by Messel in England, but only for the manufacture of SO<sub>2</sub>.

<sup>12</sup>The Clayton Aniline Co. and Nobel's Explosive Works have contact sulphuric acid plant.

<sup>13</sup>Mollinari.



TABLE I—PRODUCTION IN TONS, 1910\*

	Germany	England	France	United States	Europe	World
Sulphuric acid (H <sub>2</sub> SO <sub>4</sub> )	1,250,000	1,000,000	500,000	1,200,000	3,700,000	5,000,000
(of this by contact process)	400,000	.....	.....	250,000	.....	.....
Soda	400,000	700,000	200,000	250,000	.....	2,000,000
(of this Le Blanc soda)	30,000	120,000	.....	.....	.....	150,000
Saltpetre consumption	786,000	93,000	337,000	523,000	1,740,000	2,360,000
(of this for nitric acid)	150,000	.....	.....	50,000	.....	.....
Hydrochloric acid (30 per cent)	450,000	..*	.....	.....	.....	.....
Bleaching powder	100,000	.....	.....	.....	.....	300,000
(of this electrolytic)	70,000	.....	.....	.....	.....	150,000

\*Duisberg, "Wissenschaft und Technik," 1911.

\*\*Already in 1895 the estimated production of hydrochloric acid in England was 1 million tons, and for the whole of Europe 2 million tons (Molinari).

so familiar gas-mantles are prepared by the ignition on the cotton frame of a mixture of 99 per cent of thorium nitrate and 1 per cent of cerium nitrate.

The source of these rare earths is monazite sand, the elaboration of which has become a very important industry depending on fractional crystallization, which already many years ago was brought to such a high pitch of perfection in the laboratory of Sir William Crookes. Out of this monazite sand Hahn in 1910 succeeded in extracting mesothorium and the process is carried out on a large scale at the works of Dr. O. Knöfler and Company at Plötzensee near Berlin. Radium bromide is worth about \$85 a milligram, mesothorium about \$37.50 a milligram. The mesothorium is only present in the monazite sand in extremely small proportion, about one part in 150,000,000 parts of the mineral.

I may also refer to Auer-metal, a preparation of iron (Fe 30 per cent) containing cerium, which sparks when scratched with hard steel, and which is familiar as a substitute for matches.

Another outlet for the use of hydrogen has been in reducing the rare metals osmium (melting point 2500 deg. C.), tantalum (melting point 2300 deg. C.) and tungsten (melting point 2850 deg. C.).

In 1903 the Auer Company showed that the carbon filament of electric incandescent lamps could be replaced by an osmium filament, with an economy of 50 to 60 per cent of current. In 1905, Siemens und Halske showed that a tantalum filament was cheaper and more advantageous, and in 1906 that the tungsten filament was even still better. Tungsten occurs in sufficient quantity in nature as wolframite (iron tungstate) and scheelite (calcium tungstate) to enable the metal to be now sold as filament-metal for \$1.50 to \$1.75 a kilogram.

Some idea of the enormous and increasing scale on which the incandescent lamp manufacture is carried on in Germany may be gathered from the figures in Table II.

TABLE II—PRODUCTION IN GERMANY

	1911	1912
Metallic-filament electric lamps	47,211,892 pieces	76,185,721 pieces
Carbon-filament electric lamps	24,791,196 pieces	20,975,348 pieces
Incandescent gas mantles	126,050,954 pieces	135,320,173 pieces
Arc-lamp carbons	10,740,025 kilos	11,093,154 kilos

According to V. B. Lewes, the consumption of gas-mantles in 1912 was: Germany, 100,000,000; America, 60,000,000; England, 38,000,000; France, 16,000,000; Belgium, 3,500,000; Italy, 3,000,000; Russia, 1,500,000.

The special tax imposed in Germany on lighting apparatus realized from the above sources in 1912 was \$4,000,000.

#### AMMONIA

Of the commoner inorganic chemicals which are produced on the largest scale, one of the most important is ammonia, which has for so many years been obtained as a byproduct in the manufacture of coal gas.

So backward was this industry in Germany, that actually even as late as 1874 the ammoniacal liquor from their gas works was run to waste. All the more

remarkable is the state of affairs to-day as betrayed by the following figures. The world production of ammonium sulphate was 210,000 tons in 1890, 500,000 tons in 1900, and 1,330,000 tons in 1912. Germany's production of ammonium sulphate in 1912 was about 370,000 tons.

The principal use of sulphate of ammonia is as a nitrogenous manure, as which it competes with Chili saltpetre; they may be taken as of equal money value per unit of nitrogen. In this connection Germany's manure bill, given in Table III., is interesting.

TABLE III—GERMANY'S MANURE CONSUMPTION

	1888 Tons	1912 Tons
Chili saltpeter*	225,000	650,000
Sulphate of ammonia	50,000	500,000
Superphosphate	250,000	1,800,000
Basic slag	250,000	2,200,000
Crude potash salts	160,000	3,000,000
Lime	.....	800,000
Other manures	500,000	500,000
Total value	.....	\$150,000,000

\*The total import of Chili saltpetre into Germany in 1912 was 800,000 tons, of which only 150,000 tons was used for manufacture of potassium nitrate and nitric acid.

It is the ambition of the Germans, firstly, to make themselves independent of the industrial products of other countries, and secondly, to produce in excess of their own needs and to impose this surplus on the rest of the world. Thus, they pride themselves on displacing more and more of the foreign Chili saltpetre by home-made sulphate of ammonia, and in 1911 they used in agriculture 75,000 tons of ammoniacal nitrogen against 70,400 tons of foreign saltpetre-nitrogen. This partial success they look forward to making complete and decisive by developing new methods of producing ammoniacal nitrogen and nitrates which can be carried out in Germany.

Of such methods there are already two in operation, and they are associated with that great problem which confronts mankind as a whole. How to supply the combined nitrogen, which will be necessary to build up the food-stuffs for the teeming millions of the future, after the deposits of Chili saltpetre are exhausted? This is the same problem as that of fixing the nitrogen of the air, which long ago, before anything was known of nitrogen at all, man had solved empirically by growing leguminous plants in the rotation of his crops, thereby increasing the fertility of the soil, although the mechanism of this time-honored procedure was only experimentally demonstrated in the last decades of the 19th century by the German investigators, Willfahrt, Hellriegel and Nobbe.

#### FIXATION OF ATMOSPHERIC NITROGEN BY INORGANIC MEANS

1. This has been successfully accomplished by the Birkeland and Eyde electric furnace, and the Schönherr electric furnace of the Badische Anilin und Soda Fabrik. These are simply realizations on the industrial scale of laboratory experiments made by Cavendish 130 years previously. This method is applicable only in Norway or other countries where abundance of water power renders the production of cheap electrical energy possible. It is being carried on by an international com-

pany at Notodden in Norway. They propose to use 300,000 horse-power capable of yielding 150,000 tons lime-salt-peter (15-20 per cent N) or about one-twelfth of the total amount of Chili salt-peter used by the world. Germany possesses but little water-power so that this process is of only indirect interest in connection with German chemical industry.

2. Nitrogen may also be fixed by calcium carbide at high temperatures. This discovery was made by the German chemists Frank and Caro. \$25,000,000 capital is already embarked in this industry by various companies of Europe and America. About 120,000 tons is produced annually, about one-quarter of which in Germany. The crude calcium cyanamide (about 20 per cent N) may be used directly as a nitrogenous manure or may be made to yield ammonia. The production of calcium carbide involves the use of electric furnace and hence cannot be carried on economically on a very large scale in Germany owing to the limited water-power available.

3. Nitrogen and hydrogen may be combined at higher temperature and especially under high pressure. The long known fact that the reaction,  $N_2 + 3H_2 = 2NH_3$ , is realized to a very small extent at high temperatures has been investigated in recent years by Haber and Le Rossignol at Karlsruhe, and, guided by the principles of modern physical chemistry, Haber has elaborated, after overcoming extraordinary technical difficulties, an industrial process which promises to be of great importance in the future. The most advantageous conditions were found to be: Pressure, 200 atmospheres; temperature, 500 deg. C.; catalytic agent, osmium, uranium, etc.

Production of ammonia by the Haber process has been carried out on a commercial scale by the Badische Anilin Company since the summer of 1913, and a plant capable of yielding 130,000 tons of sulphate of ammonia per annum was to have been ready during the present year. Inasmuch as the German Color Syndicates have severed their connection with the Norwegian nitre undertaking, it would appear that they regard the Haber ammonia process as being more likely to be capable of capturing the inorganic nitrogen market of the world.

This synthetic production of ammonia obviously involves cheap hydrogen. I have already referred to electrolytic hydrogen, but there are cheaper sources. Thus water-gas contains theoretically equal volumes of hydrogen and carbon monoxide; the carbon monoxide (boiling point—192 deg. C.) can be removed by liquefaction from the hydrogen (boiling point—253 deg. C.). Similarly the nitrogen required for the process is obtainable from the fractional distillation of liquid air. The synthesis of ammonia thus dovetails with the possibilities of cheap low-temperature production for which the world is so largely indebted to the German engineer Carl von Linde of Munich.

The German ambition to make their combined nitrogen at home does not stop at the production of synthetic ammonia, for there are still large requirements in respect of nitrates (Germany produces upwards of \$7,500,000 of nitric acid annually from Chili salt-peter) which have to be satisfied from foreign sources. They hope, however, to fill this gap in the home-production of combined nitrogen by utilizing a reaction discovered by Kuhlmann<sup>15</sup> as long ago as 1839, in which ammonia and air burn to nitric acid in the presence of platinum as a catalytic agent.

#### POTASH SALTS

Germany appears to be alone in possessing vast deposits of potash salts, whilst the enormous value of

these to agriculture was first demonstrated by Liebig and made public by him in his "Application of Chemistry to Agriculture and Physiology" in 1840. This work may without question be regarded as the foundation stone on which agricultural chemistry has been raised.

The celebrated deposits of potash salts were accidentally discovered in 1857, when boring for rock-salt at Stassfurth, near Magdeburg, in Prussia. Their industrial exploitation on an ever increasing scale was begun in 1861 by Grüneberg and Adolf Frank. In 1861 the production of crude potash salts was 2000 tons; in 1912 it was 11,000,000 tons, worth \$44,000,000. Ninety per cent is used as manure (about one-third in Germany itself), and 10 per cent in industries (about two-thirds being worked up in Germany for carbonate, caustic, nitrate, alum, chromate, and chlorate, etc.). America is now experimenting with a view to obtaining potassium chloride from feldspar by the method used in the laboratory for determining alkalis in insoluble silicates, and which consists in heating the silicate with a mixture of lime and calcium chloride. Whether it has any commercial future remains to be seen.

This is a matter of prime importance in the United States, as potash salts are there used on an enormous scale, especially for agriculture. Thus they consumed in 1900 Stassfurth potash salts worth \$4,200,000; in 1910, \$12,200,000, and in 1911, \$15,200,000.<sup>16</sup>

#### EXPLOSIVES

I have already mentioned the importance of nitrates and of nitric acid, and have referred to the employment of the great part in agriculture; of the remainder the major part goes into the manufacture of explosives and into the coal tar color industry.

Black powder or gunpowder is said to have been discovered by the English monk Roger Bacon (1214-1294). Gun-cotton was discovered by Schönbein in Basle and Christian Böttger in Frankfurt in 1846.

Nitroglycerin was discovered by Sobrero in Pelouze's laboratory in Paris in 1847, and first manufactured on a large scale as an explosive by the Swede Alfred Nobel in 1862.

The disruptive properties of gun-cotton are greatly moderated by gelatinising by means of solvents (acetone, acetic ester, alcohol and ether, etc.), and by mixing with nitroglycerin ballistic materials like cordite, and other smokeless powders are obtained. There is another class of explosives which combine great safety in handling with enormous disruptive effect. Picric acid (discovered by Woulfe of London in 1771), but first used by the French under the name of Melinite for filling shells in 1881, and later by the English under the name of Lyddite. More recently this has been replaced by trinitrotoluene, first proposed by Haeussermann in 1891 for filling shells and used by the British Service under the mark "T. N. T." It is even less sensitive to shock than picric acid. "Ammonal," used by the Austrians for shell-filling, is a mixture of T. N. T. with ammonium nitrate, charcoal and aluminium powder. It is both very safe and very powerful. T. N. T. is much used for demolishing bridges. It is so sensitive to shock that it is not exploded on being struck by a rifle-bullet, and when in a shell it withstands the impact of the latter piercing an armor plate.<sup>17</sup>

Tetra-nitro-aniline, obtained by Flürscheim, enjoys the unique position among explosives of having been discovered in this country. It is said to be equally safe and even more powerful than trinitrotoluene.

According to the late Oscar Guttman, the production of nitroglycerin explosives in 1909 was as follows:

<sup>15</sup>Ann. Chem. und Pharm., 1839, 29, 280.

<sup>16</sup>Macnab. "Explosives," Inst. of Chem. Lecture, 1914.

<sup>17</sup>Molinari.



United States, 20,000; Germany, 10,300; England, 8100; Transvaal, 8000; Canada, 5000; Spain and Portugal, 3500; Austria-Hungary, 2300; France, 1500 tons; Switzerland, Austria, Norway and Sweden, 600 tons each; Russia, Italy, Holland, Belgium, 500 tons each; Greece, 175 tons.

Explosives are of enormous importance also in civil life—in mining and engineering modern explosives have greatly accelerated progress and have rendered possible such works as the Panama Canal. They are also being now employed with great advantage in afforestation for loosening the ground in which trees are to be planted. The manufacture of explosives in Germany is very highly developed. The total German production of 40,000,000 kilograms includes dynamite explosives, 10,000,000; ammonium nitrate explosives, 16,000,000 and black powder, etc., 14,000,000 kilograms. There were exported in 1908 explosives of a value of about \$5,000,000, and in 1912, \$15,000,000.

The world production of explosives is now about 400,000,000 kilograms, or 10 times the German total output. Great Britain has at Ardeer in Scotland, the largest explosives factory (Nobel's) in the world, covering 850 acres, employing 1800 men and 700 women, and producing annually about 16,000 tons of all kinds of high explosives.

#### ARTIFICIAL SILK

An eminently peaceful industry which is closely related to that of explosives is the production of artificial silk and celluloid. The manufacture of artificial silk has grown up during the past twenty-five years, for this product was first shown by Count Hilaire de Chardonnet at the Paris Exhibition of 1889; he discovered the method of its preparation while a student in the Ecole Polytechnique at Paris, and in 1891 formed a company at Besançon with a capital of \$1,200,000 for its manufacture.

The chief kinds of artificial silk are: (1) Nitrated cellulose (soluble in alcohol-ether) silk (denitrated by ammonium sulphide) (Chardonnet silk). (2) Ammoniocupric oxide cellulose silk (Pauly, Fremery, or Urban silk, of the Vereinigte Glanzstoffabrik, Elberfeld, 1897). (3) Viscose-silk ( $\text{CS}_2$  in presence of  $\text{NaOH}$  or  $\text{Ca}(\text{OH})_2$  on cellulose) (Cross and Bevan). (4) Acetate-silk (acetic acid on cellulose) (Cross and Bevan).

Germany produces about 2,000,000 kilograms, value about \$6,000,000, exports 600,000 kilograms, and imports 1,800,000 kilograms; the imported is principally "alcohol silk," due to disadvantageous alcohol tax in Germany. Germany is the principal user of artificial silk, although the fundamental discoveries upon which the manufacture is based are largely due to French and English chemists. The world production is estimated at about 7,000,000 kilograms.

The distribution of the industry may be gathered from the following: France, 7 factories; Germany, 8; Belgium, 3; England, 2; Spain, 1; Austria-Hungary, 4; Russia, 3; America, 3; Japan, 1.

Great profits have been made out of artificial silk (some of the companies paid 50 to 100 per cent dividends), and the price has greatly fallen since its introduction from \$7 per kilogram in 1903 to \$4 in 1906, and \$3 (poorer qualities \$1.50 to \$2) in 1910.

The cellulose industries furnish a particularly striking example of the manner in which chemical research and invention are able to enhance the value of the kindly gifts of the earth. Thus, 1 cubic meter of wood has value as fuel about \$1.50; (after boiling with lime, soda and sulphite) as paper pulp, \$8; ditto as paper, \$14; and as pulp converted into artificial silk, \$400 to \$1200.

#### INDUSTRIES DEPENDENT ON SYNTHETIC ORGANIC CHEMISTRY

It is out of the profound study of synthetic organic chemistry which has been made during the past sixty years that the industries of artificial dyes, drugs, and perfumes have incidentally arisen. The earlier and pioneering achievements in synthetic organic chemistry are well distributed among the nations of Europe,<sup>17</sup> but during the major part of the sixty years the great bulk of the discoveries in this domain have been made in Germany. Organic chemistry is, perhaps, the branch of science which more perfectly suits the German mind and temperament. It involves the possession of those qualities in which Germans are so pre-eminent—the capacity for taking an infinitude of pains, the capacity to anticipate difficulties and organize means to circumvent them. It is, moreover, only possible to make substantial advances in the problems of organic synthesis if the master has at his disposition a number of highly qualified and docile assistants and apprentices; in a word, the master must be at the head of a large and efficient school of research. It is in the possession of such schools of research, both in the universities and in the chemical factories, that Germany has by two generations the lead of all other countries in the world. While most of the professors of chemistry in British universities and colleges have under great difficulties and without any sort of encouragement been more or less successful in building up such schools of research, which are, however, by no means slavish imitations of the German model, the chemical manufacturers of England, have, with some notable exceptions, failed to establish anything worthy of the name of research laboratories in connection with their works.

It is in respect of the works research laboratory that there is the greatest contrast between the chemical industries of Germany, and those of other countries, and it is not surprising, therefore, that the present war should have served to emphasize the class of chemical products for which Great Britain is almost entirely dependent on Germany.<sup>18</sup> It is precisely those products—artificial dyestuffs, artificial drugs and artificial perfumes which are the outcome of the works research laboratories, that are now in many cases unobtainable in consequence of the cutting off of the German sources.

The seriousness of the situation is apparent from the following figures, relating to dyestuffs alone: The value of dyestuffs consumed in England annually is \$10,000,000, and the value of trade in which these dyestuffs are employed is \$1,000,000,000, whilst upwards of 1,500,000 workmen are dependent upon these industries. The total value of dyestuffs imported into the United Kingdom in 1913 was \$9,460,275, of which Germany contributed \$8,654,105.

Perhaps the most concise way of conveying a superficial idea of these industrial products of organic synthesis will be by means of the following classification.

**I. Artificial Products.**—Colors first obtained from aniline by Runge in 1834, by the action of bleaching powder. Aniline colors: Mauve was discovered by Perkin in 1856 and Magenta by Verguin in 1859. Azo-colors<sup>19</sup> were discovered by Griess in 1859, and introduced on an extended scale in 1878. The azo-colors have achieved an enormous importance and have practically banished cochineal and logwood from the dye-works. Some 2000 azo-colors in use. Congo-colors, substantive cotton dyes, were discovered by C. Böttiger in 1884.

<sup>17</sup>England and France were, however, more especially to the fore.

<sup>18</sup>Only about one-tenth of the annual value of dyestuffs consumed in England is produced in England.

<sup>19</sup>Both azo and eosin colors were kept as secret products, but the colors were investigated by Hofmann and their mode of production published, to the great consternation of the inventors.

It must not be supposed that British color manufacturers have been idle from the days of Perkin; thus in 1880 a very original departure was made by Messrs. Read, Holliday and Sons, who introduced the principle of developing azo-dyestuffs on the fiber with their so-called ingrain or ice colors. Some of these have achieved a great success, thus 2000 tons of p-nitraniline are now annually manufactured for the production of nitraniline-red and similar colors.<sup>20</sup> Again, the discovery of primulin and the colors which can be derived from it, by A. G. Green in 1887, is another very notable achievement.

Eosin colors were discovered by Caro in 1873.

**II. Artificially Produced Natural Products.**—This group contains substances occurring in nature and long valued by man. The chemical nature of these substances has been carefully ascertained by chemists who have then deliberately set to work to devise means for their artificial preparation at such a cost as to compete with and ultimately supplant the natural product. These campaigns against the commerce in the products of nature undoubtedly constitute one of the most remarkable phenomena in the history of the world. Bear in mind, it is the production and supply to man of the actual products of nature, but more cheaply than they can be produced and supplied by Nature herself. These endeavors have already been successful on a very large scale.

**Alizarin** (the essential principle of the madder root) was first synthesized by Graebe and Liebermann in 1869. At the time of this discovery, the world production of madder was 50,000,000 kilograms roots (1½ per cent alizarin), representing 500,000 to 750,000 kilograms alizarin, value \$11,250,000. In 1870 France had 20,000 hectares (50,000 acres) under madder cultivation, which soon disappeared after the introduction of the artificial product.

The production of artificial alizarin was: 1873, 100,000; 1877, 750,000; 1884, 1,350,000; 1900, 2,000,000 kilograms (four-fifths of this was produced in Germany).

A great number of most valuable artificial dyestuffs, more or less closely related to alizarin, but not occurring in nature, have been prepared by chemists, and the total value of the alizarin-color exports of Germany at the present time is about \$5,000,000.

**Indigo.**—This most highly prized blue dyestuff of both the ancient and the modern world was first artificially synthesized by Adolf Baeyer in 1880, but it required seventeen further years of unremitting and laborious investigation in the works of the Badische Anilin und Sodafabrik at Ludwigshafen, and the investment of nearly \$5,000,000 before laboratory synthesis was translated into a commercially successful industry, for it was in 1897 that the artificial indigo was put on the market.<sup>21</sup>

In 1896 the world production of plantation indigo (100 per cent) was 6,000,000 kilograms, value \$20,000,000; four-fifths of this was British, obtained from 1,500,000 acres in British India. In 1904 only 500,000

acres was under cultivation, and in 1913, only 300,000 acres (see Table IV.).

The price of indigo (100 per cent) in 1897 was \$4 per kilogram and in 1913 \$1.75 per kilogram.

By varying the ingredients in the indigo-synthesis, many very valuable dyes related to indigo have been obtained. Thus the chlorine and bromine substituted indigos are manufactured as ciba-blue, brilliant-indigo and bromo-indigo. Again with sulphur instead of oxygen, thio-indigo-red, and thio-indigo-scarlet are obtained. Moreover, by using the anthracene-grouping in the indigo-synthesis a number of most important colors have been obtained, *e. g.*, indanthrenes, of extraordinary fastness to light; alizarin-indigo; algol-colors (Rob. E. Schmidt), in all varieties of color, and of the greatest fastness to light. The discovery of these valuable dyestuffs provoked zealous emulation on the part of the azo-color chemists, who responded by placing some very excellent new products on the market under the name of benzolight colors.

**Antique or Tyrian purple** was perhaps the most highly prized of all colors in the ancient world. We know from Pliny that this dye was obtained from a rather rare snail living in the Mediterranean, and which he describes under the name of "purpurea." Paul Freidländer, of Darmstadt, succeeded in 1909 in extracting this color from certain glands of two different species of snail—*murex brandaris* and *murex trunculus*—which appeared to correspond to Pliny's description of "purpurea." He removed these glands from 12,000 individual snails, developed the color by a short exposure to sunlight, extracted it with suitable solvents and recrystallized it from quinoline. In this manner he obtained only 1½ gram of the coloring matter, so that its extreme costliness, which Freidländer estimates at about \$10,000 a kilogram, is not surprising.

On investigating the chemical nature of this color he found that it was identical with the already known synthetical compound 6,6'-dibromindigo.

**Drugs and Perfumes.**—Not less remarkable are the achievements of organic synthesis in connection with pharmaceutical and perfumery products.

The production of artificial drugs and perfumes is in general only a branch of the artificial color industry, for in many cases the raw materials are the same, while the methods of investigation and synthesis are, of course, identical. But whereas the artificial color industry started in England, that of artificial drugs is entirely of German origin, and may be said to begin with the discovery by Liebig of chloroform in 1831, and of chloral hydrate in 1832. It was in 1869 that the chemical works of Schering, on the suggestion of A. Liebreich, produced chloral hydrate as a commercial article.

In 1887 began the discovery of artificial antipyretic drugs, the rivals of the natural quinine. The first of these was antifebrin, the properties of which were discovered accidentally in consequence of a mistake. A specimen of acetanilide in a Strassburg pharmacy was erroneously supposed to be naphthalene, and was served out as such for some pharmacological experiments by Kahn and Hepp. On being taken, internally, its antifebrile effect was observed. Fortunately there was enough left for analysis, and it was found that the supposed naphthalene was the long known acetanilide, which soon acquired a great vogue for this purpose. About the same time antipyrin was discovered by Knorr, who erroneously thought that it was chemically related to quinine, and that it would, therefore, not improbably possess antifebrile properties. Direct experiment showed that it did actually possess these properties in a high degree, but subsequent research showed that it was in no way chemically related to

TABLE IV—INDIGO

	British East Indies		Germany	
	Cwt.	Exports, Value	Imports	Exports
1896.....	188,337	\$17,848,350	\$5,180,000	\$1,597,750
1899.....	135,187	9,901,595	2,077,250	1,961,250
1902.....	89,750	6,174,185	921,750	4,615,500
1905.....	49,252	2,782,025	300,500	6,430,250
1908.....	32,490	2,124,245	220,500	9,663,750
1911.....	16,939	1,125,000	111,500	10,457,500
1913-14.....		\$300,000 to \$350,000		

<sup>20</sup>G. T. Morgan, "Modern Dyes and Dyeing," Roy. Dublin Society, 1914. C. N. and J. F. Thorpe, "The Synthetic Dyestuffs and Intermediate Products," 1913.

<sup>21</sup>Baeyer's first patent for the synthesis of indigo from o-nitro-cinnamin acid was taken out in 1880, and by 1907 there had been no less than 316 patents obtained in Germany for processes connected with the preparation of indigo.



quinine. These and numerous other artificial antipyretics have been a great source of income to their inventors in consequence of the continued prevalence of influenza during the past quarter of a century.

During the period that antipyrin was protected by patent it was sold at \$30 per kilogram, while on the expiration of the patent the price was reduced to \$5 per kilogram, which still allows a good margin of profit.

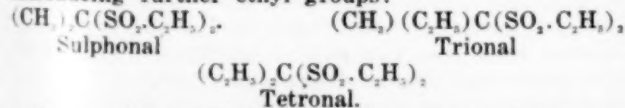
These discoveries have led to the systematic study by direct experiment on animals and human beings of innumerable chemical compounds with a view of ascertaining their physiological properties. The enormous amount of most laborious work which has been carried out in connection with synthetic drugs may be gathered from the fact that up to 1912 about 5000 artificial products had been found to possess therapeutical value of one kind or another, but, of course, comparatively few of these have permanently established themselves in medical practice. Time does not permit me to do more than refer briefly to some of the simpler and better known synthetic drugs.

Thus of antipyretics, which have or have had some considerable vogue, are: Antipyrin; tolpyrin (dimethyltolylpyrazolone); salipyrin (antipyrin-salicylate); antipyrin mandelate (tussol, for whooping cough); neopyrin; pyramidon (three times as strong as antipyrin) (dimethylamino-antipyrin); antifebrin; phenacetin (cheapest antipyretic excepting antifebrin, about \$1.50 per kilogram, and less poisonous than antifebrin); lactophenin, lactyl-p-phenetidine; aminophenacetin or phenocoll (also has an antiseptic action).

The above series derived from aniline affords a good illustration of the dependence of physiological properties on chemical constitution. Aniline itself is a powerful antipyretic, but is extremely poisonous, owing to its ready absorption and action on haemoglobin. By introducing the acetyl group the toxic properties are much reduced owing to its greater stability, although acetanilide is slowly hydrolyzed with liberation of aniline, so that after a time the symptoms of aniline poisoning may supervene. The observation that acetanilide is partially oxidized in the system to *p*-aminophenol led to derivatives of the latter being tried. Thus phenacetin has been found to possess powerful antipyretics and greatly reduced toxic effects<sup>22</sup>

**Hypnotics.**—Sulphonal was accidentally discovered to possess hypnotic properties in connection with experiments on the transformations of sulphur compounds in the animal system. A dog, which had been dosed with the newly discovered sulphonal, in Baumann's laboratory at Freiburg, i.B., was found to fall into a deep sleep.

More powerful hypnotics were found to result from introducing further ethyl groups:



In connection with the manufacture of sulphonal, I may refer to an interesting difficulty which was experienced by the Elberfeld Color Works owing to the appalling smell of the mercaptan from which it is prepared, and of which Emil Fischer and Penzoldt have shown that the human nose is still capable of appreciating 1/400,000,000 mgrm. In spite of this, German thoroughness has been successful in so perfecting the apparatus in which the manufacture is carried on that no nuisance is occasioned.

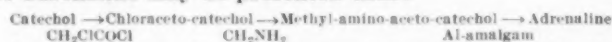
Veronal (diethylbarbituric acid) (E. Fischer and Mering, patented by Merck in 1903) is one of the most widely used hypnotics. Although it was formerly sup-

posed to be practically free from toxic properties, in recent years cases of veronal poisoning have been known to occur.

**Antineuralgics.**—Salicylic acid, one of the first drugs to be artificially prepared (Kolbe, 1860), acetyl-salicylic acid (aspirin), and salol (phenylsalicylate), though extremely simple synthetic products, are almost exclusively made in Germany, with the result that their price has now greatly increased. Even synthetic phenol which is necessary for the above preparations, was exclusively made in Germany and kept down the price of coal-tar phenol. The price of phenol has now enormously increased from 7 cents per lb. to 33 cents per lb., and is likely to go higher. (Pharm. Journal, 1915.)

**Anti-gout drugs** (Uric acid solvents).—Piperazine (discovered by Hofmann in 1890), lysidine, urotropine (hexamethylene tetramine), atophane (*a*-phenylcinchonic acid).

**Suprarenine.**—This is of special interest. The active principle of the suprarenal glands known as adrenaline<sup>23</sup> had for some years been found to be of great value for increasing the blood-pressure, contracting the blood-vessels, and arresting haemorrhage. It requires the suprarenal glands of 40,000 oxen to prepare 1 kilogram of adrenaline, but this substance has been artificially synthesized by F. Stolz, and is put on the market as suprarenine by the Höchst Color Works. The synthesis of adrenaline may be presented thus:



Natural adrenaline is laevo-rotatory; the synthetic can be resolved by tartrate; the laevo is 15 times as potent as the dextro.

The German color manufacturers are organized into two principal groups or trusts (Interessengemeinschaften). (1) Badische Company, of Ludwigshafen; Bayer Company, of Elberfeld; Berlin Aniline Company. (2) Cassella Company, of Frankfurt; Meister, Lucius, und Brüning, of Höchst.<sup>24</sup>

The share-capital of the above two groups in 1911 was \$40,000,000 paying a dividend of 25.8 per cent, and probably now about \$60,000,000 dividend, 28 per cent.

In 1860-70 Germany imported about \$12,500,000 worth of dyes per year, while in 1912, Germany exported about \$50,000,000 and produced about \$62,500,000 of dyes.

The composition of the personnel who carry on these German color works is at the bottom of their success. Take the Works of Messrs. Meister, Lucius, und Brüning as an example. In 1913 the composition was as follows: Workmen, 7680; managers, 374; expert chemists, 307; technologists, 74; commercial staff, 611. Contrast with the above the fact that the six English factories now producing dyestuffs employ altogether only thirty-five chemists, while evidence of their relative activities is again furnished by the circumstance that between 1886 and 1900 the English firms took out only eighty-six patents, whereas the six principal German firms were responsible for 948 during the same period.

Having shown that these German coal-tar color manufacturers are without rivals from the commercial point of view, I feel it to be my duty to point out also that their industry is carried on under conditions of labor which are highly creditable to the management.

This vast and highly organized industry of dyestuffs and fine chemicals, which is certainly one of the most outstanding manifestations of the modern German spirit, were formerly very dependent on England for its chief raw material, coal-tar, and it is interesting to

<sup>22</sup>Discovered by Takamine in 1901.

<sup>24</sup>"German Coal Tar Companies," Textile Mercury, Jan. 9, 1915.

<sup>23</sup>Chemistry of Synthetic Drugs, P. May, 1911.

see in Table V how effectually Germany has emancipated herself from a control which might at any time become irksome or even paralyzing.

TABLE V—GERMAN COAL-TAR PRODUCTION  
Coke Ovens, Tons      Gas Manufacture, Tons

1897.....	52,000	
1900.....	93,000	
1904.....	277,000	225,000
1908.....	632,400	300,000

In 1908, 40,000 tons was still imported from England, and in 1909, 18,000 tons, but 35,000 was also exported.

In 1900 the German production of coal-tar was only about one-half of that produced in England, while by 1912 it had equalled if not surpassed the English production. Again, in 1880, Germany used 1400 tons of pure anthracite of which only 200 tons was of German origin, while at the present time the 5000 tons now employed in Germany is all produced there.

The phenomenal increase in the German coal-tar production has depended on a similarly rapid development of the German iron and steel industry, which has entailed an enormous demand for metallurgical coke in the production of which the greatest attention has been devoted by Germany to the recovery of the byproducts—tar, gas, ammonia, etc.

In England the quantity of coal-tar treated was 175,000 tons in 1870, and 640,000 tons in 1880; at present over 750,000 tons is treated.

*Synthetic Perfumes.*—With regard to the synthetic perfume industry, the facts are in many respects essentially similar to those in connection with the artificial dyestuffs. The production of artificial perfumes, in many cases the identical substances which are produced by nature, has assumed very large proportions in Germany, the annual output being estimated at about \$12,500,000. It is particularly noteworthy that one of the first steps in the realization of this remarkable achievement of artificially building up the natural perfumes was also made by William Henry Perkin, who in 1868 succeeded in synthesizing coumarin, the highly valued odoriferous principle of the woodruff (*asperula odorata*).

The effect of artificial synthesis on the price of natural perfumes may be gathered from Table VI.

TABLE VI

	Price of 1 Kilogram	
	Natural	Synthetic
Coumarin .....	\$125	\$6.25
Vanillin .....	250	7.50
Hellotropin .....	750	2.50

#### THE CHEMICAL SITUATION IN GREAT BRITAIN

The facts which I have brought forward speak for themselves and proclaim in the most convincing manner the stupendous progress which has been made by Germany in the chemical industries during the past 40 years. It is equally certain that England, once pre-eminent for chemical manufactures, has not progressed at the same rate and is at the present moment suffering much inconvenience through being so largely dependent on German chemical products of one kind and another. The country is now reaping the harvest of humiliation which it has sown for itself in spite of the warning repeated *ad nauseam* by the chemical profession during a whole generation. The systematic neglect of chemical science and the failure by manufacturers to utilize the services of highly qualified chemists, could only lead to the result that all the industries which are dependent on a profound knowledge of chemistry should tend to disappear from England's midst and pass into the hands of those who are prepared, not only to apply new chemical discoveries to industry, but even to prosecute the most varied chemical investigations in the hope of sooner or later making discoveries which shall be of advantage to their commercial undertakings.

The mischief caused through the neglect of chemistry by practical men in this country has been so subtle that to a large extent it has remained concealed from the average man of intelligence and from the governmental classes. During the past 40 years our country has been accumulating wealth in an altogether unprecedented fashion, so that the loss or restriction of some industries appeared a matter of unimportance to political observers taking only a broad and superficial survey of the national resources. The whole of our arrangements have evolved during the past half century on the assumption that this country would never again be engaged in a European war, while still more recently the new democracy has vainly boasted that it could prevent such a war by means of a general strike. The year 1914 has seen the dissolution of many fool's paradises and has given the *coup de grace* to all these vain imaginings, with the result that we find our vast textile industry in serious peril because the much smaller dyestuff industry has been complacently allowed to slide into the hands of our sagacious and more painstaking enemies. The same carelessness and want of foresight had even allowed us to become dependent on Germany for some of the most important materials used as explosives, *e.g.*, trinitrotoluene, and for many of the most valued drugs required alike by our army, navy and civil population.

The complete breakdown in our supply of fine chemicals, which is the direct outcome of the disregard of the constant warnings emitted by scores of British chemists, has led the Government of the day to intervene and attempt to remedy the intolerable state of affairs which has arisen in connection with the supply of coal-tar colors.

#### THE PROPOSED BRITISH COAL-TAR INDUSTRY

We devoutly hope that success will attend the endeavor to establish the coal-tar industry in these Islands on the largest possible scale. Whatever the ultimate scheme adopted may be, I would venture to point out that it must be based on a clear understanding of the following considerations:

1. That the provision of the required chemicals during the continuance of the war is one thing, and that their production on a commercial basis after the cessation of hostilities is quite another matter.

2. It appears to me that in order to provide the needful supply during the war, the only reasonable course is to assist in every possible way those firms which are already making similar or closely allied products so as to enable them to produce their present goods on a larger scale, and as far as practicable to undertake the manufacture of others which are urgently required. The immediate problem will be also greatly facilitated by utilizing supplies obtainable from neutral powers, and more especially from Switzerland, which is the only country, other than Germany, in which the manufacture of dyestuffs and similar chemical products has been vigorously prosecuted. As a matter of fact, Mr. Runciman admitted in the House a short time ago that the Government had granted licenses to trade with the enemy in the matter of dyestuffs.

3. As regards the prospects of the home industry after the war, it will require "nursing." I use the term advisedly in order to obviate the employment of another and much more familiar one which is so dear to some politicians and so hated by others; it will require nursing for a much longer period of time than has hitherto been mentioned. In this connection I would point out that the sum of \$50,000 a year for ten years, which it has been proposed to guarantee for research purposes, is absurdly inadequate.

4. If the industry is to prosper it will not only have to manufacture materials already known, but also con-



tinually to be introducing new products of its own discovery, as well as constantly to be seeking to produce more economically a great number of auxiliary chemicals required in the manufacturing processes. It is also essential that the undertaking should branch out into the manufacture of other materials as occasion may arise for advantageously utilizing byproducts.

5. The competition which the industry will have to suffer from Germany is likely to be much more serious than is generally supposed, because it must be remembered that England only takes, as we have seen, about one-fifth of the total German exports of dyestuffs, so that it would be comparatively easy for German firms specially to reduce the price of the goods sent to England. They have already done this in America when attempts have been made to start an aniline industry there. It is particularly significant, and augurs ill for the prospects of this scheme, to rehabilitate the coal-tar color industry, that the latter has failed to flourish anywhere, excepting on German soil, and that countries with fiscal systems entirely different from our own have been no more successful in this respect than have we ourselves.

6. It will certainly be necessary that expert chemical knowledge should in the future be much more highly remunerated than it has been in the past, otherwise the supply of able and properly qualified men will not be forthcoming. The flow of men of high-grade intelligence into a profession is determined by the prizes which the profession has to offer, in the form of money and social position. Consider the great stream of able men who are attracted to the English Bar, in which profession the prizes, although limited in number, are of the most substantial kind, with the result that the successful leaders are selected by the fiercest competition in a very wide field.

If there is to be a large influx of high intelligence into the chemical profession, it will be necessary that there should be some very different prizes from the paltry bait which is offered at the present time, for the study of chemistry in this country now only draws those men who either have or think they have an overpowering zeal and passion for the science, to which they devote themselves against the advice of their friends, and in spite of the warnings of the professors of chemistry, by whom they are initiated.

Notwithstanding the absence of material inducements, I venture to say without fear of contradiction that there is more original investigation being prosecuted in this country by chemists than by any other body of British men of science, and this I attribute to the fact that such a large proportion of our number have either been at German universities or are the pupils of those who have been at these centers of research. Nor are any of us, I am sure, even during this unfortunate crisis, unmindful of the hospitality and the inspiration which we have received in the schools of the enemy.

7. If the proposed undertaking is to succeed, real chemists must be on the directorate, and in a sufficient proportion to give effect to their views. Many men of science are excellent business men. What does experience teach in the case of flourishing chemical industries which we fortunately still have among us? What does not the firm of Messrs. Brunner, Mond & Co., for example, owe to the late Dr. Ludwig Mond, F.R.S.?

8. In attempting to establish a commercially successful coal-tar company on a large scale in this country, I venture to think that the Government have undertaken a task which they will find to be surrounded with difficulties of quite a different order from those which they have had to encounter in some of their most striking previous legislative acts, such as the provision of salaries for members of Parliament, the granting of Old

Age Pensions, and the establishment of a compulsory system of Insurance. These are matters in which if the Government dictate we are obliged to obey, but the commercial success of an industry which is based upon progressive scientific investigation depends upon factors so subtle and elusive that they cannot be coerced even by a majority of the House of Commons.

9. If the chemical industries are to be rehabilitated in England, there must be a complete change in the attitude of mind towards science in general, and towards chemical science in particular, among the influential classes of the population, and it will certainly not be effected by following the precept "business as usual," but by pursuing a policy which is the exact opposite of what is implied by that vulgar and undignified phrase.

## Synopsis of Recent Chemical and Metallurgical Literature

### Potash in the United States

In discussing the possible sources of potash in the United States before the New York section of the Mining & Metallurgical Society of America, Mr. A. H. ROGERS mentioned the work of the Government on the brines and deposits in desert basins, also the investigations on alunite in Utah, and the possible utilization of the giant kelps of the Pacific coast. Mention was made also of the potash-bearing silicates, feldspar and leucite. The former contains about 16 per cent and the latter 21 per cent potash. In speaking of the work of Cushman and Coggeshall on extracting potash from feldspar, Mr. Rogers said: "This includes fine grinding of feldspathic material and mixing with 20 per cent of burned lime. This mixture is deposited in a thin layer on a belt which travels under an arrangement which allows drops of a concentrated solution of calcium chloride to fall on it. The result is the formation of little balls having considerable hardness which, being screened out, are fired in an ordinary cement kiln; such of the powdered rock as has not been agglomerated is returned to the head of the belt. The heated agglomerates contain the potash of the feldspar as chloride, which is then leached out and recovered by evaporation. Messrs. Cushman and Coggeshall have experimented on a large scale with this process, and as the results of their work have estimated that potassium chloride can be produced for \$31.32 per ton, or about 62 cents per unit  $K_2O$ ."

Speaking of experimental work on leucite, Mr. Rogers continued: "We have tried both wet and dry treatment; the former has been possible because, in contrast with feldspar, leucite is very easily decomposed. Another curious feature about leucite is that, in distinction from most silicates, when decomposed by wet acids it yields its silica in granular form and not gelatinous. We found that by treating with sulphuric acid, to which a little hydrochloric acid was added, complete solution of the bases resulted, and we thought that this might solve our problem. However, it speedily developed that the mixture of sulphates was about as hard to separate into its constituents as the rock. Digestion of leucite with caustic lime under a high pressure was also tried, and this procedure was varied by using caustic soda, and even sodium chloride, the idea being that soda might replace the potash better than lime. From all of these tests some results were obtained, but not enough to be encouraging. Treatment of the rock with sulphurous acid gas at temperature ranging up to 1200 deg. C. was tried, and also the Hargreaves process, which is employed for making sodium sulphate out of salt by passing steam and  $SO_2$  over the salt at a temperature of about 500 deg. C. These yielded a little soluble potash,





**Effect of Carbon in Contact with Auriferous Cyanide Solutions.**—The subject of precipitation of gold in cyanide solutions by forms of carbon is again discussed in *Bulletin No. 127, I. M. M.*, by Mr. W. R. FELDTMANN. He has had occasion to investigate the precipitating action of some "graphitic" ores, and has gathered other data on charcoal precipitation. The graphitic or carbonaceous schists of West Africa precipitate gold from cyanide solutions, and the low extractions obtained there are partly due to reprecipitation of gold by the schists. An analysis of the graphitic schist shows 10.80 per cent "graphite, etc." (by difference). The close analogy between the actions of West African graphitic schists and charcoal is shown in the following points:

1. Gold is precipitated (in the case of the schist in a measure roughly proportional to the amount of carbon present).
2. The gold thus precipitated is not soluble to any appreciable extent in fresh cyanide solution.
3. It is to a large extent soluble in alkaline sulphides.
4. After dissolving the gold in alkaline sulphides the precipitating capacity of both schist and charcoal is renewed practically in its entirety.

The author summarizes his conclusions as follows:

1. It has been demonstrated that the graphitic schists of West Africa precipitate gold from auriferous cyanide solution in a manner which is, in all important respects, analogous to the action of charcoal under like conditions.
2. The gold is precipitated on the charcoal (and on the schist) not as metal but as a compound—possibly a carbonyl aurocyanide.
3. The gold compound is decomposed and the gold dissolved to a considerable extent by alkaline sulphide solutions (judging by the results of a large number of tests, the re-solution is effected rather more easily from the schist than from charcoal).

Whether the discovery that alkaline sulphide solutions will dissolve gold which has been precipitated on the carbonaceous schist can be turned to practical utility in the cyanide treatment of ores containing such schist, is the subject of experiments at present being carried on. By post-treating, with sulphide solutions, sand residues from which a maximum possible extraction had previously been recovered by cyanide treatment, a further extraction has been obtained from a large number of samples, and there is some promise that an economical post-treatment may be evolved on these lines. The precipitation of the gold from the sulphide solutions (in which the gold is held as alkaline aurocyanide with hardly any free alkaline cyanide, but a large excess of alkaline sulphide) appears to be best effected by contact with metallic copper.

**Effect of Mineralized Waters in Cyanide Mills.**—At some of the cyanide plants in western Australia where good water cannot be obtained it is necessary to use water heavily charged with mineral sulphates, chlorides and carbonates. What is locally known as "fresh" water is obtained from shallow wells, while "salt" water comes from underground drainage. Both classes of water have to be used at the Sons of Gwalia. A description of their use and treatment is given by Messrs. THOMAS B. STEVENS and W. S. BRADLEY, in *Bulletin No. 127, Inst. of Min. & Met.* Analysis of the "fresh" water shows 1.6643 grams solids per liter, while the "salt" water contains 55.744 grams solids per liter. The principal salts are sodium chloride, magnesium chloride and sulphate and calcium carbonate and sulphate. From their experience the authors make the following recommendations for the use of mineralized waters:

1. If "salt water" is used it is not usually possible to obtain a protective alkalinity, but it is advantageous to

add a small amount of lime in order to make use of the protective action of precipitated magnesium hydrate.

2. A mixture of "salt and fresh waters" is to be avoided, as dilution of the sodium chloride present causes precipitation of insoluble calcium and magnesium salts, but if they have to be used the addition of lime to produce a protective alkalinity is to be desired.

3. The use of all "fresh water" is by far the most satisfactory, but sufficient lime should be added to it to render it alkaline before it is introduced into the treatment plant.

4. Unless there be other adverse reasons against it, crushing in cyanide solution is to be favored when using mineralized water, as the quantity of "make-up water" required is kept at a minimum by doing so.

A great deal depends on knowing the exact composition of the water, and work done in finding out exactly how the positive radicals contained in the dissolved salts are combined with the negative radicals is time well spent.

### Tube-Milling

**Injector for Tube-Mill Feed.**—In *Bulletin No. 127, I. M. M.*, Mr. N. CARLESS describes a device used at the Waihi Grand Junction mill for feeding pulp to the tube-mills. The injector is shown in Fig. 2.

"In the smaller mills the feed nozzle is 1¼ in. inside diam. The nozzles discharge into a larger pipe which

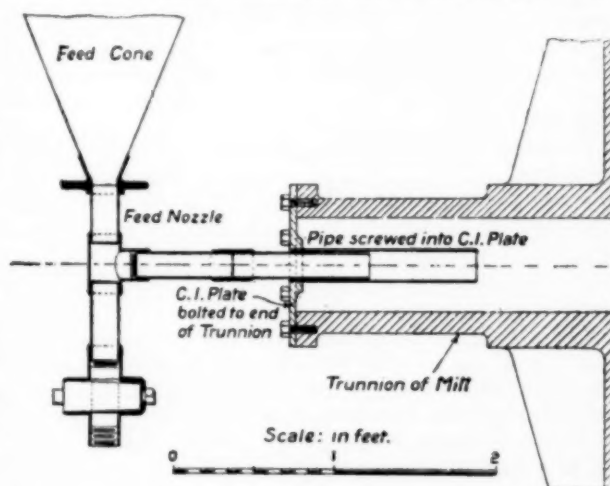


FIG. 2—INJECTOR FOR FEEDING PULP TO TUBE MILL

is bolted on to the end of the tube-mill. A clearance space of ⅛ in. is left around the feed-pipes, hence the pulp discharging into the mill causes a current of air to enter between the two pipes, thus preventing any chance of overflow of pulp at the inlet end.

"It has been found that the best results take place when the pulp passing into the tube-mill contains about 40 per cent of moisture. Experimental work is in hand, with a view of introducing thicker pulp into the mills."

### Flotation

**Testing Oils for Flotation Process.**—An outline of methods for testing oils for the flotation process is published in *Australian Mining Standard* for April 8, 1915, by Mr. J. Coutts. Of the many tests required for this process, one of the most important is the testing of the active floating agent. Conditions of the test should follow as closely as possible the presumed actual conditions of operation. The following remarks pertain mainly to eucalyptus and resinous oils.

Certain standard materials are necessary. (1) Ore sample: A thoroughly representative sample of the material to be treated is dried, crushed to pass 60-

mesh screen, and weighed into 1-lb. lots ready for use. (2) Sulphuric acid: A solution containing 0.405 grams  $H_2SO_4$  per liter, 1 cc. of which equals 2 lb. pure acid per ton, when working with 1 lb. of ore. (3) Oil: A standard oil sample is that oil which has been found to meet the requirements of the work, upon which all future calculations are based and comparisons made. It is stored for use in suitable bottles. (4) Hydrometer: one reading to 0.001.

"In all cases it is necessary to ascertain the sp. gr. of the oil with the view, at least, to future calculations; this may be carried out at any suitable temperature which has been fixed upon as standard; it has been found advisable to check the sp. gr. of the standard oil simultaneously, because of the gradual increase in sp. gr. which takes place owing to the loss of lighter oils by volatilization. A correction for temperature is made by allowing 0.00045 for each deg. Fahr.

"Oil Dropping.—A small burette is used for counting the number of drops in 1 cc. of the oil, also for admitting the oil to the machine during testing operations. The greater the number of drops per 1 cc. delivered by the burette, the greater the accuracy of the test; to obtain a suitable dropper, cut a burette about 8 in. above the cock, almost close to the discharge orifice by dumping up the glass with a blowpipe flame, then grind the outside back to a point so that a minimum surface is presented to the oil drop. The burette should at normal temperatures drop between 80 and 90 drops per 1 cc., when run at the rate of 1 drop per second. The temperature of the oil during dropping test should correspond with the temperature during flotation test.

"Calculations.—Having obtained the number of drops per 1 cc. and the sp. gr., it is easy to calculate the number of pounds of oil per ton of ore, when working on 1 lb. of sample.

Thus 
$$\frac{2240 \times \text{sp. gr.}}{453.6 \times \text{No. drops per cc.}} = \text{lb. of oil per ton of ore.}$$

"Miscibility.—It is sometimes desired in practice to use a mixture of oils. When the oil under examination is to be used in conjunction with another, or other oils, they should be wholly miscible in the proportions in which they are to be used.

"The following classification and explanations will serve to convey to the reader a general idea of the methods employed when carrying out various tests:—

(1) Flotation of lead, zinc and other sulphides, as a mixed concentrate; (2) differential separation or selective flotation of one sulphide in the presence of other sulphides. The term "differential separation" is usually applied to the selective flotation of lead sulphide from zinc and other sulphides; (3) flotation of copper and iron sulphides.

"General Outline of Scheme of Test.—The testing of oils in the laboratory is carried out by comparing measured quantities (from 3 to 6 drops) of a standard oil, with a similar quantity of the oil under examination; the values being arrived at by comparing the results obtained from each series of tests. Tests are usually made on 1 lb. of standard ore sample in 4 lb. of water at a standard temperature, acidulated with a definite quantity of sulphuric acid; the oil then being admitted; the mixture is agitated in a specially constructed agitating machine, the principle of which being dependent on the object of the test. The float produced is skimmed off, dried, weighed and assayed.

"Test 1.—The flotation of mixed sulphides. Almost any eucalyptol oil which produces a persistent froth, and leaves a gummy residue on evaporation, is suitable for this class of work, the test being carried out

as described. An agitating machine may be constructed by cutting a winchester bottle about 10 in. above the neck (a bell jar of suitable dimensions can be obtained), fit four copper baffles 4 in. x  $1\frac{1}{2}$  in. wide to a copper band of the same width, push this arrangement hard down into the bottle (the band being first bent to fit the inside circumference of the bottle), the lower ends of the baffles will jam hard at a point where the concave glass begins; the band is then expanded hard against the glass, and held in position by soldering the separated ends. The mouth or discharge end is closed with a rubber stopper, through which is passed a glass or metal tube, fitted with a short rubber tube and clip. The bottle with the baffles in position is inverted and clamped centrally under two pairs of suitable bearings, which carry a  $\frac{1}{2}$ -in. impeller shaft; at the upper end of the shaft is fitted a driving wheel, and at the lower end a four-bladed impeller, which just has clearance between the lower points of the baffles and the glass; the blades of the impeller have a lateral angle of about 45 deg., and should be driven at about 1200 revolutions per minute, in a lifting direction.

"Test 2.—Differential separation. For differential separation, an oil high in phellandrene is used, which leaves a gummy residue on evaporation. Phellandrene may be tested for by a polariscope. Differential separation is worked in acid and neutral, and in hot and cold liquors, and being still in its infancy, allows of many types of machines and schemes being applied; each different ore requires some modifications, but the principle in main is the addition of medium and aeration from below, which is effected by air jets or suction created by the impeller.

"Test 3.—Flotation of copper and iron sulphides. An oil which gives a deflection by the polariscope of 60 or over is considered sufficiently high in phellandrene for use in copper flotation. Tests are usually made with the apparatus described in Test 1, using cold circuit liquors made slightly acid. In practice the mine water usually contains sufficient acid for the purpose."

### Iron and Steel

**Automobile Gears.**—ROBERT R. ABBOT, metallurgist of the Peerless Motor Car Company, has contributed quite an interesting article on "an example of the development of heat treatment" to the *Sibley Journal of Engineering*. Gears form a very essential part of an automobile. Originally carbon steels were used and they were cyanided; but the hardened surface film was very thin and the gear teeth would fracture. Carbonizing was then employed as the hardened shell can be made as deep as desired. But there is a lack of toughness in a carbonized gear tooth and this led to the use of alloy steels and their heat treatment. Many gears were made of chrome, nickel, and silicon steels containing about 0.5 per cent carbon and were oil-quenched and drawn without carbonizing. The carbon was low enough so that no cementite was present. The alloy gave an extremely strong tooth; the cost of machining was higher than for a low-carbon steel. Such a surface would not wear as well as one containing a higher percentage of carbon. A marked step in advance was then made in the development of the so-called double treatment of carbonized parts; this is applied to either a plain or an alloy steel. When a piece of carbonized steel is hardened at the ordinary hardening temperature, there are three different zones. But if a temperature higher than the hardening temperature is used, the excess substance in the inner and outer zones, namely iron and cementite, becomes less in amount while the martensite becomes greater; briefly the martensite absorbs both the iron and ce-



mentite. As the temperature is raised still further this absorption continued until finally all three zones contain martensite alone. The temperature at which the last of the cementite is absorbed will usually be different from that at which the last iron goes into solution; also the time element for the absorption of the cementite is much greater than for the iron. The temperature of final absorption of the iron increases as the amount of iron originally present in the core decreases. Also the temperature of final absorption of the cementite is higher as the temperature at which the original carbonizing took place is higher. This temperature can also be changed by suitable selection of the material with which the carbonizing is done. In general, all the above factors are adjusted so that the temperature of final absorption of the iron shall be higher than that for the cementite. If the steel is now quenched from above this temperature, there is martensite throughout, but there is a difference in the physical characteristics of the martensite in the three original zones; that in the center zone will be fine grained, while that in the middle and outer will be very coarse. Steel treated in this way will be less brittle than when at the lower hardening temperature, but it will not wear so well because the cementite is no longer present and this is the hardest constituent formed in steel. If the steel is now reheated to the regular hardening temperature, i.e. 1375 deg. to 1400 deg., and then quenched, there is an enormous increase in toughness and also in hardness and wear resisting ability. Microphotographs show that both zones contain the same constituents and in the same relative proportions. However, the structure is entirely different, the cementite in the outer zone no longer exists as brittle sheets, needles or nets, it is uniformly distributed in minute globules which have a maximum durability of wearing surface with a total lack of the former extreme brittleness. The core is very fine-grained and the martensite instead of occurring in a comparatively few large crystals which would tend to promote brittleness now occur as fine crystals embedded uniformly in a matrix of soft iron.

#### Electrolysis in Concrete Structures

Paints to prevent electrolysis in concrete structures have been investigated by Mr. HENRY A. GARDNER, who presents the results of his tests in the March, 1915, *Journal of the Franklin Institute*. The author concludes that the use of properly made paints on metal embedded in concrete is a safeguard that should not be neglected by the engineer. In the preparation of such paints the vehicle should contain: Boiled or bodied oils or products which dry to a fairly saturated film; oils which dry by semi-polymerization rather than oxidation; oils which dry to a flat rather than a glossy surface. The solid portion of the paint should contain a percentage of pigments which are coarse and tend to form films having rough surfaces; which are inert and do not act as electric conductors; which are either basic or of the chromate type. The painted metal should be coated with sand before drying in order to afford a good bonding surface for the concrete.

**Hydraulic Forcing and Miscellaneous Presses** is the title of Sectional Catalog No. 92, issued by the Watson Stillman Co., 50 Church Street, New York. It is an illustrated book of 128 pages, describing the many special types of hydraulic presses made by this company, such as wheel presses, crank pin presses, armature presses, broaching presses, forcing presses, die presses, projectile capping and banding presses, baling presses, briquetting presses, smokeless powder presses, carbon squirting presses, lead presses, crayon presses, etc.

## Recent Chemical and Metallurgical Patents

### Iron and Steel

**Steel Refining.**—Mr. W. R. WALKER of the U. S. Steel Corporation, patents the following combination process for steel refining. He introduces molten pig metal into a Bessemer converter and blows it until the silicon and incidentally a large proportion of any manganese which may be in it has been eliminated and the carbon reduced to a definite percentage, preferably to about 0.05 per cent, which percentage can be gaged with accuracy because it is about the percentage contained in the metal at the time when the flame "drops." He then adds to the desiliconized and decarburized metal sufficient carbon to raise its carbon content to a definite percentage, preferably 0.3 per cent. The metal is now enriched in carbon to the same percentage as steel is; it is also deoxidized. It is, in fact, steel but containing an excess of phosphorus, sulphur, etc.

This phosphorus and sulphur is then removed by treating the metal in an electric furnace or an open-hearth furnace. (13,861, Jan. 5, 1915.)

**Steel Alloys.**—A method of producing silicon-steel, vanadium-steel and other steel alloys is patented by Mr. ARCHIE SMITH, of Leetonia, O., and assigned to the Youngstown Iron and Steel Co. In the ordinary method of making such alloys, the steel is tapped directly into a ladle containing the alloying metal. According to the improved patented process, the steel is tapped first into an intermediate ladle from which, in turn it is tapped into the ladle containing the alloying ingredient. The advantages claimed are the exclusion of slag from the alloy, and the possibility of making use of refining furnaces of any size, so that a large quantity of steel can be refined, charged into an intermediate ladle and then alloyed in smaller charges in the mixing ladles. (1,131,799, Mar. 16, 1915.)

**Treating Mill Scale.**—A method of reducing the mill scale formed in the manufacture of high-speed steel, is the subject of a patent granted to Mr. FREDERICK M. BECKET, of Niagara Falls, N. Y. By smelting such scale with silicon as a reducing agent, in an electric furnace and in accordance with certain methods disclosed in prior patents, it may be reduced to an alloy having approximately the same composition as that of the steel from which it was derived. Analyses of a mill scale and the alloy obtained therefrom by silicon reduction, are as follows:

	Mill Scale	Reduced Alloy
Tungsten	11.90	15.60
Chromium	2.90	3.40
Vanadium	0.49	0.43

The resulting alloys, however, contain an unusually high percentage of phosphorus, and the product of direct reduction of the scale is low in tungsten. These conditions can be obviated by a preliminary acid treatment, where the major portion of the iron and practically all of the phosphorus are removed. Thus the scale is ground to 8-mesh and treated with sulphuric acid of 1.2 to 1.4 sp. gr., either at normal temperature or at from 50° to 70° C. The residue is washed and smelted with silicon. Up to 75 per cent of the iron can be removed by the acid without material loss of tungsten, and the resulting alloy will contain from 25 per cent to 45 per cent tungsten and be practically free from phosphorus. According to a modification of the invention, the mill scale is subjected to a reducing operation with carbon before acid treatment. The mixture of scale and carbon is heated to about 1000° C. in a retort, and then treated as above described. (1,127,162-3, Feb. 2, 1915.)

## Gold and Silver

**Agitator.**—Fig. 1 illustrates the features of an agitator, patented by Mr. JOHN V. N. DORR, of Denver, Colo. The apparatus is designed to treat ores by cyanidation, or for the thorough mixture and treatment of finely divided solids in a liquid capable of dissolving a constituent of the solids. The device embodies both air and mechanical agitation, and effectually prevents the accumulation of banks or beds of settled solids within the tank. It consists of a circular tank in which is suspended an upright, hollow, rotatable conduit 3, carrying from its lower extremity two or more radial arms 10, provided with blades or plows 12. Near the upper end of the central conduit are arranged two or more distributing launders 16. The central conduit and attached arms and launders are rotated by means of a worm 8 and wheel 7 above the tank. Compressed air is admitted at the bottom of the conduit through a pipe 24 extending downwardly within the conduit from above, or it may be applied through the bottom of the tank.

In operation the radial arms and plows convey the settled pulp to the central conduit where it is raised by the air-lift to the launders and distributed over the surface of the pulp in the tank. Operation may be continuous through a succession of agitators, the pulp being fed in at one side of the tank, as at 19, and removed at the other side, as at 20. By adjusting the means of discharge, the density of the pulp can be controlled. (1,131,222, March 9, 1915.)

## Copper

**Use of Sulphur Dioxide in Electrolytic Copper Process.**—It has been previously proposed to make use of sulphur dioxide to prevent the harmful action of ferric salts in the electrolysis of impure copper solutions. According to a patent granted to MARCEL PERREUR-LLOYD, of Boulogne-sur-Seine, France, the method of application has hitherto been defective, and it is the object of his invention to make effective use of this substance as a depolarizer. This he claims to accomplish by bringing about an agitation of the electrolyte. Such agitation can be done either by moving the electro-

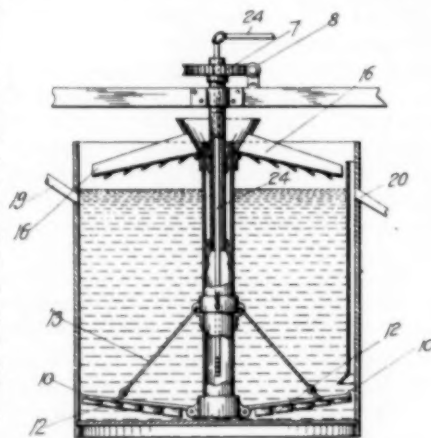


FIG. 1—AGITATOR

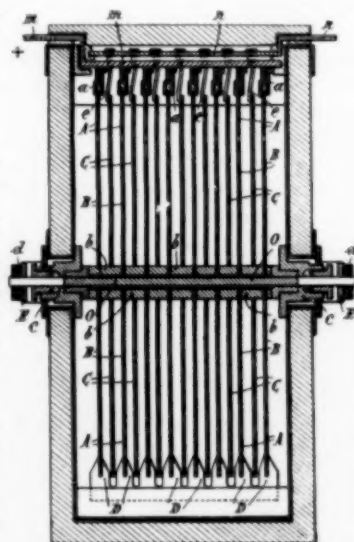


FIG. 2—CELL FOR ELECTROLYTIC COPPER

lyte by means of compressed air or by moving the anodes in the electrolyte. The former method has the objection of driving sulphur dioxide out of solution, hence the latter method is preferred. As shown in Fig. 2, one method of moving the anodes is to cause them to rotate in the electrolyte, being moved about a shaft to which they are attached. The cathodes C are stationary. The anodes, which are composed of two parts, A and B, are partly stationary and partly rotatable, A being attached in a stationary manner and B attached to the rotating shaft O. With sufficient agitation of the electrolyte, keeping the sulphur dioxide in solution, it is possible to employ a current of 100 amperes or more per square meter of cathode area and to extract copper from the most impure solutions up to 0.1 per cent and obtain good deposits of copper. It is claimed further that with this apparatus the required electric energy can be reduced to less than one kilowatt hour per kilogram of copper deposited. Sulphuric acid is generated in the course of the process from the sulphur dioxide which, in turn, is cheaply generated from the process of roasting ores. (1,133,059, Mar. 23, 1915.)

## Notes

**Air-Lift Pumping** is the title of a bulletin recently issued by the Sullivan Machinery Co. It contains valuable data and information on the subject.

The **Dorr Cyanide Machinery Co.** announce that after May 1, 1915, the address of their New York office will be Room 2843, Whitehall Building, New York City, instead of 30 Church Street, as heretofore.

The **Kelly Filter Press Co.**, Salt Lake City, Utah, has issued a new pamphlet illustrating and describing the Kelly filter press. The company maintains a large testing plant where products can be tested to determine capacity, filtering medium, operating cost and other data.

The **Association of Iron and Steel Electrical Engineers** held a meeting on April 10 at the Seventh Avenue Hotel in Pittsburgh, Pa., a paper by Mr. A. W. Soderberg, of the Carnegie Steel Company, on "Apprenticeship and Educational Work in the Iron and Steel Industry" being on the program. Another meeting was held on May 1, when Mr. R. S. Wile, president of the Wile Electric Furnace Company, presented a paper on the electric furnace and the melting of alloys in the electric furnace.

The **Liberty Bell mine**, Telluride, held its first annual "Safety First Dinner" on April 8, "to celebrate a year without a fatal accident and with fewer serious accidents; to pledge ourselves to better care in future." This is a new and effective method of bringing the "safety first" idea prominently before the employees of a company. The dinner was followed by five-minute talks by General Manager Charles A. Chase, Mill Superintendent W. E. Tracy and others. The evening was enlivened by "safety first" verses sung to the tune "Tipperary."

**Water Meter.**—The Yarnall-Waring Co., Chestnut Hill, Philadelphia, has just received orders for four Lea V-notch recording liquid meters in combination with Webster feed-water heaters aggregating 1,125,000 lb. per hour capacity, from the E. I. duPont de Nemours Powder Co., Wilmington, Del., following the original installation of the Lea system by them two years ago. They also report an order for a 275,000-lb. per hour capacity Lea V-notch recording liquid meter for the new power plant of the Victor Talking Machine Co., Camden, N. J.



## Fuel-Supply Contracts and the Progress of More Scientific Methods of Purchase and Control in America and Europe

BY JOHN B. C. KERSHAW

That the application of scientific methods for determining the sale and purchase value of fuel is advancing in favor, is proved by the growing literature of the subject, and by the increasing tendency of power engineers in the leading industrial countries, to demand guarantees from the colliery companies, or from the coal dealers and "middlemen," that the fuel shall yield on test a minimum number of calories, or shall contain less than a definite maximum percentage of sulphur and ash.

These newer methods of purchase and control have obtained their widest application in America, a result due partly to the fact that the American Government has taken up vigorously the system of purchasing fuel on a heat-unit basis, and partly to the greater readiness of American business men to give science its proper place in the control of industrial and manufacturing operations.

In Europe the necessary incentive to adopt more scientific methods has been supplied by the advanced labor legislation of recent years, and by the striking rise in the cost of coal mining in the leading industrial countries. The additional financial burdens placed upon the colliery owners have, in fact, rendered the use of scientific methods for checking the quality and price of fuel imperative, for not only has the price of fuel been increased by 20 per cent to 30 per cent within the last few years, but the quality has at the same time deteriorated, and every large fuel-user knows only too well that he is now paying more for a worse fuel than ten years ago.

The (British) Eight-Hours-Day Act has been the chief factor in causing this deterioration in the quality of the fuel mined, a deterioration which is most marked in the case of the slack and small coal sold in large quantities for steam-raising purposes. In order that the miner may produce his daily quota of output he has to work with less care than formerly, and a much larger proportion of shale and dirt is now brought to the surface with the coal than was the case ten years ago.

The proportion of smalls in every 100 tons of coal raised has also increased enormously since the Mines Eight-Hours Act came into force. The writer of this article has tested quite recently a large delivery of slack sold by a well-known Lancashire colliery company for steam-raising purposes which gave the following results when graded in the laboratory:

Slack left on 1/4-in. mesh sieve.....	48 per cent.
Fine slack which passed through 1/4-in. mesh sieve .....	52 per cent.

The latter portion of the slack was again graded into two portions by use of a 1/12-in. mesh sieve and it was found that nearly one-half of this portion, or 24.3 per cent of the original weight of slack, was composed of fine dust that passed easily through a 1/12-in. mesh sieve. Separate ash tests of these three grades of slack were then made and the test results are sufficiently interesting to be given here:

Slack left on 1/4-in. mesh sieve....	11.15 per cent ash.
Fine slack, between 1/4-in. and 1/12-in. mesh .....	19.20 per cent ash.
Dust under 1/12-in. mesh.....	29.60 per cent ash.

Nearly 25 tons of every 100 tons of this slack as delivered was therefore practically valueless as a fuel in

any ordinary boiler furnace, and in this particular case it only served to clog up the air passages of the fire-bars and to prevent proper combustion of the remaining 75 per cent of the fuel. To charge \$3.25 per ton for such a slack was a gross imposition upon the fuel-user. Instances of a similar kind could be given in large numbers, but enough has been said to prove that during the past ten years the quality of fuel has deteriorated enormously while the price has increased, and that the need for the application of scientific methods of controlling the quality and price of fuel was never more urgent than at the present time.

In this article details will be given of the methods in use in Germany, Switzerland, the United Kingdom and America for sampling and testing fuel in transit, or when discharging at the consumer's works. Some examples of forms of contracts, in which the price paid for the fuel is made dependent either upon the calorific value, or upon the percentage of ash will also be given.

*Germany.*—The information relating to German methods has been obtained from Dr. Aufhäuser, head of the Thermochemische Prüfungs-und Versuchs-Anstalt in Hamburg. The fuel testing for the members of the *Hamburg Verein für Feuerungsbetrieb und Rauchbekämpfung* is carried out at this laboratory, and the last annual report of the above society contains the results of many hundreds of tests of samples of English and German coals, which have been made in Dr. Aufhäuser's fuel-testing laboratory. A large number of members of the *Verein für Feuerungsbetrieb* are now having their supplies of fuel sampled and tested regularly, the usual plan being to take separate samples of each 50 tons of coal as delivered, and to have these samples tested for moisture and ash, and also for calorific value, in a Berthelot-Mahler bomb-form of calorimeter. In some cases the purchasers of the fuel have been able to arrange for contracts with the "middlemen," or colliery agents, in which the price paid varies with the monthly average of these calorimetric tests, the basis of the contract being a fixed price for 100,000 calories. In other words heat units and not coal are bought and sold.

In the majority of instances at Hamburg, however, only two limits are inserted in the contract, namely, a *minimum calorific value* and a *maximum percentage of ash*. The seller of the fuel then contracts to deliver a fuel which shall not fall below a certain stated calorific value, or contain above a certain stated percentage of ash, and if any delivery of fuel is found which does not fulfil these conditions of sale it is either returned to the seller or an allowance is made on the price.

*Average tests* of the monthly deliveries are taken in deciding upon the value of the fuel and slight variations up to 1 or 2 per cent are generally overlooked. Very bad or dirty samples are quickly detected by the wide deviation of the test results from the average of the deliveries, and the tests of such samples are not included in the average, unless the sampler is convinced they represent fairly the deliveries on the particular occasion when they were taken.

Although the colliery companies and "middlemen" prefer this form of contract to the former one, it is really the more rigorous of the two, for it contains no possibility of the price being increased, when the fuel actually supplied is rather better than that contracted for. The simpler form of contract is, however, preferred; and not only in Hamburg but also in many other industrial centers of Germany the supplies of fuel are now being purchased under what is practically a chemical guarantee of quality. Over 1000 samples of fuel were tested at Hamburg in 1909 and the work of Dr. Aufhäuser's laboratory has increased greatly in the four years that have elapsed since that return was published.

*Switzerland.*—The facts and figures relating to the progress of fuel sampling and testing in Switzerland have been obtained from Prof. E. J. Constam, director of the federal fuel-testing laboratory at Zürich. The erection and equipment of this laboratory was one result of the purchase of the Swiss railways by the state in 1902 and of the fact that all the fuel required for working the railways was purchased in France or Germany, generally in the form of briquettes.

The laboratory is an annex of the Zürich Polytechnic and is really an extension of the old thermo-chemical laboratory, the extensions and equipment costing about \$10,000 and having been completed in 1907. In the year 1908 (the first of its existence) over 3300 samples of fuel-briquettes and coal were tested in this laboratory, and the latest available figures show that this has been increased to 5860 in 1912. The laboratory examines fuel for private firms and individuals, as well as for the state railways, and from time to time the results of its investigations are published in the form of a report.

As the value of briquettes depends largely upon their ability to stand handling without falling to pieces, an important test at this federal laboratory is that for "cohesion." This test is carried out as follows: Fifty kilograms of the briquettes are put into the drum of the cohesion testing machine in  $\frac{1}{2}$  kg lumps. The machine is set in motion and, after making fifty turns in two minutes, the contents is emptied onto the gridiron and shaken. What remains behind is weighed. This is expressed as a percentage of the weight used and gives the cohesion value, which in the case of good briquettes should not be less than 55 per cent.

The large number of tests carried out at this state-aided laboratory has had good results in Switzerland for it has tended to enlighten the consumers as to the relative economic values of the fuels they have been importing from the various countries, and has assisted in their classification according to heating power.

The director of the federal fuel-testing laboratory, Dr. Constam, is a firm believer in the use of the thermal value of a fuel as the basis of the fuel-contract, and he is doing all he can to get this system of purchase adopted in Switzerland.

Both the coal producers and the consumers are stated to be satisfied with the methods of fuel sampling and testing adopted at the Zürich laboratory. The results of the tests are compiled monthly and are communicated to both the sellers and buyers of the fuel. In the case of briquetted fuel the settlement is effected by adding to or deducting from the price a proportionate sum for every 90 B.t.u. by which the average monthly calorific value of the fuel actually delivered differs from the standard calorific value inserted in the contract.

*The United Kingdom.*—Although a very large amount of fuel-testing is being carried on in the United Kingdom at the present time in the laboratories of technical colleges and universities, of independent experts, and of works and factories, it is not easy to give an exact record of what is being done since the English manufacturer and works-manager is extremely unready to make his methods of control and management known, even when these contain little that is novel or of patentable value. It is certain, however, that in a large number of works and factories where fuel is an important item in the costs of production the deliveries of fuel are regularly and systematically sampled, and that these samples are tested either in the laboratory attached to the works or are sent to some independent institution or analyst for examination.

With regard to the form of the fuel-contracts used in the United Kingdom little progress has been made yet in persuading the colliery companies or the coal dealers

to sell coal on a sliding scale basis, *i. e.*, to sell calories or heat-units in place of tons of coal.

The majority of fuel contracts are based, however, on the system of guaranteeing a certain definite standard of quality expressed in British thermal units and in percentages of moisture and ash. Should the coal actually supplied not come up to this standard of quality the delivery may be rejected. This form of contract suffers from the grave defect that in nine cases out of ten the fuel is discharged and is partly or wholly used before the deficiency in heat units or high percentages of moisture and ash are discovered. The rejection of the fuel is, therefore, a course which can rarely be adopted, and as the colliery company is protected in this manner from the operation of the clause, the adjustment of price, which ought to follow the delivery of bad fuel, seldom occurs.

The systematic sampling and testing of the fuel which is going on, however, has some effect in keeping up the quality of the fuel delivered. A contract with a clause defining the quality of the fuel purchased in B.t.u. and setting limits to the allowable percentages of moisture and ash, is certainly an advance upon the form of contract in use fifteen or even ten years ago, when only the mine and seam of coal were named in the clause specifying the quality.

Some practical examples of the forms of contract that have been tried or are now in force in the United Kingdom are given below. These are drawn chiefly from the electrical supply companies, since the engineers of these undertakings are quite ready to answer inquiries, and the writer is most in touch with what is being done in this branch of the engineering industry.

*A. A Large Municipal Electrical Supply Undertaking in Scotland.*—The chief engineer reports that samples are taken daily of all the coal, a small scoopful of coal being taken by the check weighman from each ton-load delivered. These small samples are stored in a clean receptacle until the barge or wagon is empty. The sample is then reduced by crushing and quartering to one of 3 lb. and this is forwarded in a sealed tin to the testing laboratory of the electricity department. The contents of the tin are there crushed and still further reduced in bulk in the usual manner and the calorific value of the sample is finally determined in the bomb type of calorimeter.

If the tests show that the fuel being delivered is below the standard set for the particular pit from which it is shipped complaint is immediately made and the cause of the deterioration in quality is usually found to be *careless mining and picking of the coal*. By this means the engineer of this works reports that they have obtained a thorough working knowledge of the relative values of all the fuels mined within a practical distance of the generating station and when offers of coal are made they can bring all prices down to a common calorific basis by use of their past test records for each pit. Although the contract is not based on heat units they are able to bring the contract price into close agreement with the real calorific value of the fuel.

*B. A Large Municipal Electrical Supply Undertaking in the Midlands.*—The chief engineer and general manager reports that the fuel is sampled and tested daily. Samples are taken from the rotary filler supplying a conveyor at intervals during the unloading of each boat, the coal in this case being delivered by canal. Each day's samples are mixed and are quartered down into two lots of convenient size. One of these is tested for calorific value, ash and moisture daily, the other portion is put with the previous day's sample in order to make up the weekly average sample of fuel.

The Contract stipulates for a certain calorific value



and ash percentage but the price is not dependent upon the quality. This latter must, however, be maintained or the fuel can be rejected, and if not rejected a claim can be made for a reduction in price based on the average figures of tests taken over the period in question.

*C. A Large Municipal Electrical Supply Works in the North of England.*—The borough electrical engineer reports that tenders are invited for fuel to a specification which records the minimum calorific value of the fuel and also the maximum percentage of ash. When the tenders are received certain fuels are picked out for testing purposes. A sample lot of 100 tons is asked for (this is equal to one day's supply) and the whole of the works is then run on this sample lot, the weight and cost of fuel per unit generated and the percentage of ash made being carefully noted. In addition to this practical test a laboratory test is made from a sample sent to an analytical chemist. The contract is placed with the firm whose sample of fuel shows the best practical results per unit generated, but regular analytical tests of the fuel are made during the period for which the contract runs and a clause is inserted in it giving power of cancelling the contract in the event of the fuel not coming up to the guaranteed calorific value. The laboratory tests are therefore used in this case solely to check the quality of the fuel delivered.

*D. A Large Cotton-Spinning Company with a Mill in the Manchester District.*—This company managed to obtain in 1908 a contract with a Lancashire colliery company on the sliding-scale basis but after a two years' trial the contract was not renewed. This non-renewal was due to the objection of the colliery company to the terms of the contract and to their refusal to be bound by them, even when the fuel supplied was better than that contracted for and the price variation was in their own favor.

While this contract was running two carefully prepared average samples were tested per month by an independent analyst. These samples showed a striking uniformity in ash contents and calorific value, the variation from the calorific value of the sample upon which the contract was based being well within 5 per cent for the whole of the period. This uniformity in the heat-value of the coal actually delivered was, no doubt, largely due to the knowledge that the coal was being regularly sampled and tested at the consumer's works. The consumers recognized this fact themselves, and stated in a letter to the author that "we are greatly in favor of the system of purchase upon calorific units. Since our contract of December, 1908, when we began the new system, we have had a much more uniform fuel supplied to us, which is all we aimed at."

*E. A Flour-Milling Company with Several Mills in Southwest Lancashire.*—This company, like that cited above, found a firm of colliery proprietors willing to close a contract on the sliding-scale basis.

The experience of the second firm, however, has been rather different from that of the first, since marked variations occurred in the quality of the fuel supplied, and in consequence there were considerable reductions made in the price paid for the fuel. It is noteworthy that the largest increases in ash and corresponding decline in calorific value occurred during the second half of the year 1909, although the coal merchants declared they were supplying exactly the same fuel as in the earlier months. This falling-off in the quality of the fuel contracted for lends support to the assertion that the operation of the mines eight-hour act is affecting the quality of the small coal raised and sold in certain mining districts.

In this case, also, the sliding-scale arrangement ceased at the end of 1910 owing to a change of man-

agement at the mill and the appointment of a manager who did not believe in the value of fuel-testing.

In concluding this account of the progress of the movement for the more scientific control of fuel supplies in England, reference may be made to a standard coal specification for the purchase of coal by electricity works. This specification was drawn up by a committee representing the principal London firms of coal contractors on the one hand and the Associated Municipal Electrical Engineers of Greater London on the other.

There are two model specifications, the first being for a coal of a particular description or "named" coal; while the second is for a coal guaranteed to possess certain definite physical qualities.

The principal feature of this latter specification for "guaranteed coal" are as follows:

The tenderer shall set out in his details the classes of coal for which he is tendering corresponding with the classes referred to in the table of standards.

*Testing*—(a.) A representative sample shall be taken on delivery from each or any consignment and shall be divided and sealed in three air-tight vessels. The contractor shall be at liberty to be represented when the sample is taken, and shall be entitled to one portion thereof; but he shall have no opportunity at a later date of objecting to the manner in which the coal has been sampled.

(b.) Samples taken in the manner defined shall be taken from each consignment and tested by the purchaser, or in the event of a dispute by a competent expert, who shall be approved from time to time by the purchases and whose fees shall be paid by the contractor if the purchaser's test is confirmed. The tenderer is invited to set out in the tender's details, the names of three experts either of whom he is agreeable shall be employed. A table of standards is then given for application in connection with guaranteed coals. As regards the methods of testing the fuel the following conditions are laid down:

British thermal units shall be ascertained on coal dried at 220 deg. Fahr. for an hour by means of a Mahler-bomb calorimeter. Moisture shall be represented by the total loss in weight of the coal delivered after air-drying and exposing to a temperature of 220 deg. Fahr. for one hour. The percentage of sulphur shall be based on the analysis of the coal "as received" and must not exceed 2 per cent. The sieves used for determining the percentages of "small" shall be of square mesh with openings in the clear to the sizes given.

*America.*—As already stated earlier in this article the United States Government has given a strong lead in America to the scientific control of fuel supplies by purchasing a large proportion of the coal required for the navy and other state departments on a B.t.u. or strictly specified basis. As regards the naval requirements the fuel is purchased on a B.t.u. basis, a premium being paid for all coal showing more than 15,000 B.t.u. in the dry state, and no wet coal being accepted. The balance of the government's annual coal purchases is bought on a pro rata as received B.t.u. basis and the seller is also penalized to the extent of from two cents to thirty-five cents per ton for variation in ash rising from 3 per cent to 9 per cent above the guaranteed amount, 2 per cent above the guarantee being allowed to pass without fine. The method of sampling and of calculating the heat-value is as follows:

In all cases where practicable the coal is sampled during its discharge into the building where used. The sample selected in no case is less than 100 lb. and it must be reduced by repeated crushings and quarterings to the small amount required for testing by the treas-

ury department. The method of analysis and of calorific valuation is that drawn up by the American Chemical Society.

Payment is made upon the basis of the price named in the proposal for the coal specified by the seller, correction being made for the variation in ash and heating value. For example, if the coal contains 2 per cent more or less B.t.u. than the standard named in the specification the price is increased or decreased in the same proportion.

The price is also corrected for the percentage of ash, and for all coal which contains less ash than the standard named in the specification a premium of 1 cent per ton is paid for each 1 per cent of ash. An increase of 2 per cent of ash over the standard named in the specification, on the other hand, is not weighted with a penalty, but above this limit a deduction is made from the price paid for the coal. The coal is to be weighed as delivered, and as payment is made upon this delivery weight the calorific test is made upon the coal containing whatever moisture may be present at the time.

With regard to other methods or systems of purchase in use in America, the Fuel Engineering Company, of Chicago, was founded in 1908 as an independent sampling and testing organization with a large number of clients who purchased fuel on a B.t.u. basis and handed over all the scientific work required in connection with this method of purchase to the officers of the company. The company published a monthly test sheet for circulation among its clients giving details of all the tests made during the previous month. Much valuable information concerning the comparative value and price of the fuels marketed in Chicago thus became the common property of all who were having regular tests made by this organization of their fuel deliveries, and each consumer found out quickly if he was obtaining a good return for his expenditure upon fuel. The specification and method of regulating the price by the quality used by the Fuel Engineering Company, of Chicago, was more complicated than that used by the United States Government departments and was based upon what was called the "contract guarantee," or number of B.t.u. which was obtainable for 1d. (2 cents) from the trial sample of the fuel.

The *Interborough Rapid Transit Company* is an electric tramway company which consumes annually 360,000 tons of a bituminous "run of the mine" coal. This is purchased upon a B.t.u. basis—with limiting values of 9 per cent for ash and of 1.5 per cent for sulphur. Variations above or below these figures are subjected to deductions or premiums as the case demands.

The coal for the *Panama Canal constructional works*, which amounted to 650,000 tons per annum, was also purchased on a B.t.u. basis of 14,600 as received, with deductions for variations below this limit.

The *Department of Water, Gas and Electricity Supply for New York City* uses a very large quantity of coal per annum and the system of fuel control employed is considered by its officers to be an improvement upon the system used by the United States Government departments. According to the description of the system given in *Power* by F. R. Hutton and J. L. Pulz, before drawing up definite specifications a careful investigation is first made of the character of the various coals furnished in the buyer's area, and from these results a diagram is plotted representing the variations in moisture, ash, volatile matter, sulphur and combustible matter. Any coal falling within the limits considered desirable are put on the list of eligibles as to quality: Coals lying outside these limits and below them are penalized with respect to weight, but not as to price, so that the buyer should not buy water or incombustible mineral matter

and pay for them at the rate agreed on for good coal. The research carried out on these lines by the company's staff developed the relation that each percentage of ash in the coal besides displacing 1 per cent of combustible matter has a retarding effect (varying with the quality of the coal) equivalent to the withdrawal of between 145 and 155 B.t.u. or an average of 150 B.t.u. With this as a basis, a formula was evolved applicable both to anthracite and bituminous coal in the following form:

$$\text{Corrected tonnage} = \text{tonnage delivered} \times \frac{\text{B.t.u. per lb. as delivered} - 150 \text{ B.t.u.} \times \text{excess percentage of ash}}{\text{B.t.u. per lb. as specified in standard analysis}}$$

For practical purposes the formula can be simplified by using a direct percentage relation whereby 1 per cent in weight shall be deducted for each 100 B.t.u. and an additional 1 per cent for each percentage of ash. This can be equally well applied when it is desired to give a bonus.

The weight of the coal after correction for moisture is then reduced at the rate of 1 per cent for each percentage of ash in excess of that permitted by the standard and the gross dry weight after correction for moisture is reduced at the rate of 1 per cent for each 100 B.t.u. below the standard heating value. The gross dry weight is also corrected at the rate of 5 per cent for each 1 per cent. of volatile sulphur in excess of the standard. These corrections are then aggregated and deducted as a whole, payment being made only for the balance of the gross weight at the price bid per unit furnished, delivered and stored and trimmed (if so specified in the schedule).

These examples will show that purchases on a B.t.u. basis is the rule rather than the exception with large fuel users in the United States and that there are many different ways of carrying this out.

As proof of the interest taken in the subject of fuel sampling and testing in America, the publications of the Bureau of Mines at Washington may be referred to. The following list of bulletins is by no means complete, but it shows how well the subject has been covered.

- 1908. Bulletin 339.—The Purchase of Coal under Government and Commercial Specifications, on the Basis of its Heating Value.
- Bulletin 362.—Mine Sampling, and Chemical Analysis of Coals Tested at the U. S. Fuel-Testing Plant, Norfolk, Va.
- 1909. Bulletin 378.—Results of Purchasing Coal under Government Specifications. 1907-1908.
- 1910. Bulletin 428.—Results of Purchasing Coal under Government Specifications. 1908-1909.
- Bulletin 27.—Tests of Coal and Briquettes as Fuel for House-heating Boilers. By D. T. Randall; 44 pp.; 3 pls.; 2 figs.
- Bulletin 28.—Experimental Work Conducted in the Chemical Laboratory of the United States Fuel-testing Plant at St. Louis, Mo., January 1, 1905 to July 31, 1906. By N. W. Lord; 51 pp.
- 1910. Bulletin 41.—Government Coal Purchases Under Specifications with Analysis for the Fiscal Year 1909-1910. By G. S. Pope, with a Chapter on the Fuel-Inspection Laboratory of the Bureau of Mines. By J. D. Davis, 1912; 97 pp.; 3 pls.
- Technical Paper 1.—The Sampling of Coal in the Mine. By J. A. Holmes, 1911; 18 pp.; 1 fig.
- Technical Paper 8.—Methods of Analyzing Coal and Coke. By F. M. Stanton and A. C. Fieldner, 1912; 21 pp.; 5 figs.
- Technical Paper 26.—Methods of Determining the Sulphur Content of Fuels, Especially Petroleum Products. By I. C. Allen and I. W. Robertson, 1912; 13 pp.; 1 fig.

The *Cusi Mining Company* of Chihuahua, Mexico, has recently installed a 5-ft. by 16-ft. adjustable quick-discharge tube mill of Chalmers & Williams.



## Is Duplexing Slated for Assassination?

BY JOSEPH I. PEYTON

Duplexing of late years has been the subject of much criticism, especially in regard to the quality of the product, by various engineers and users of rail steel.

It has only recently been brought to light that one of the main causes of duplex steel not comparing favorably with that of the straight open-hearth practice was due to the fact that in the converting department, where the molten metal is blown, the manganese originally in the blast furnace or mixer metal was nearly all eliminated, *i.e.*, most of the manganese went into the slag as manganese sulphide and manganese oxide, while some volatilized, passing out of the converter as a gaseous product. Then when the blown metal was transferred to the open-hearth furnace for further refining, there was naturally a shortage in manganese content, which is so necessary in the open-hearth furnace, to assist in reducing sulphur from the steel, and at the same time preventing the occurrence of overoxidation of the metal.

To obtain a good quality of steel, a good quality of slag is absolutely essential as well, and to obtain this a sufficient amount of manganese should be present. In duplexing, formerly, there was no addition to the manganese content of the blown metal, other than the amount contained in the direct mixer metal, which is charged into the open-hearth furnace for the purpose of raising the carbon content of the bath, until just before tapping or directly afterwards, thus the benefit of having a sufficient amount of manganese present throughout the operation was lost. The present practice, however, of adding manganese to the blown metal differs in different plants, largely due to conditions.

Some use a high-manganese mixer metal and add a small quantity to each ladle of blown metal before it is transferred to the open-hearth furnace. Another method is to use sufficient steel scrap containing enough manganese to give the bath the desired content. Others use an ore with a high manganese content as a part of the open-hearth furnace charge or in the working of the heat, and where conditions are not so favorable ferromanganese or spiegeleisen is charged, preferably after part of the molten charge has been made in the open-hearth furnace. Since the adoption of this practice duplex steel has rolled as well as the straight open-hearth steel, proving that duplex steel has the quality.

Another improvement in duplexing of vast importance, not so much in improving the quality of steel, but in saving time in working the heats, is the elimination of the Bessemer slag from the open-hearth furnace. Bessemer slag is most variable in volume, due entirely to conditions, and contains considerable quantities of silicon dioxide, which when entering the open-hearth furnace changes the constituency of the slag of the furnace, making it necessary for additional lime to flux the silicon dioxide of the Bessemer slag and on account of the fluctuating volume of highly silicious slag from the Bessemer, it renders it difficult for metallurgical calculation to take care of it in the initial charging of the furnace. However, the recent methods of straining blown metal through either a stoppered ladle or one of the cupola-tap type, leaving the slag in the ladle, has helped the situation to a marked degree, both as to the time and ease on the furnace linings.

No doubt many consumers of steel have had the impression that duplex steel on account of its being made much faster and with fewer units involved than in straight open-hearth practice was a moneymaker for the manufacturer, but as a matter of fact, it costs the manufacturer more to make duplex steel than it does to make straight open-hearth steel, except when the

price of scrap is excessive. The metallic loss in the Bessemer converter department is very high as compared to the metallic loss in the straight open-hearth process, and the metallic loss in a duplex basic Bessemer is about double the metallic loss in the duplex acid Bessemer. It is this huge metallic loss in the Bessemer department that makes the cost greater to the manufacturer.

To duplex economically the units must be large and in close proximity, which means a minimum waste and a minimum labor cost. So many of the plants engaged in duplexing work under distressing conditions as to cost and metallic loss, which is due to the size of the units and their arrangement principally. The most efficient duplex mill in existence is located at Steelton, Pennsylvania, and it should produce results on duplexing well worth knowing.

Several prominent metallurgical men who know that duplex steel possesses quality, have said that if the discard in the ingot could be reduced to 5 per cent, duplexing would be absolutely necessary on account of the high price that scrap would then assume.

It is a fact well known to all metallurgists that something to prevent the enormous waste in shearing to obtain sound steel, *i.e.*, steel free from piping and segregation, would be most welcome to the steel industry. For that reason many men have come forth with suggestions, methods, processes and inventions for the producing of sound ingots. Most of them, however, are impractical and a few cost too much per ton of steel produced to ever be of any commercial value to the manufacturers of the cheaper grades of steel.

The few methods in use find a market only where high-grade, high-priced steels are manufactured, which steel can afford a considerable tariff for the betterment of the product. Three methods in use are the Harmet or pressure process, which is very expensive, and is only used on high-grade steels, such as high-grade marine shafting, etc., the anti-piping thermit method, which costs 35 cents per ton of steel produced, and the Hadfield method, with a refractory sand ring in the molds head, using charcoal to cover the ingot top just after the teeming of the molten metal into the ingot mold with a forced gas flame playing thereon, which method costs 25 cents per ton of steel produced for the sand ring and claims to cut the discard to as low as 8 per cent. Even this method is hardly to be considered in connection with the cheap steels, for aside from the cost, it must require considerable labor and time to equip the molds each time before the teeming of the molten metal into them.

For that reason there has been developed a new type of ingot mold, upon which patents have been issued, which is cheap, practical and economical. It is cheap from the standpoint that there is practically only one cost (the initial cost) and when considering the average life of an ingot mold, it cuts the cost to a matter of only a few cents per ton of steel produced. It is practical because these molds are as ever ready as the molds in common use to-day. It is economical from the standpoint of a sounder ingot, which should offset the cost thereof many times. It has within the mold itself the most efficient heat insulator known, that is, a vacuum chamber, as shown in the accompanying figure. It is known as "Peyton-Hitt vacuum chamber ingot mold."



INGOT MOLD WITH  
HEAT-INSULATING  
VACUUM CHAM-  
BER

### Instrument Exhibit at San Francisco

The Bristol Company, Waterbury, Conn., have a large exhibit of their extensive lines of recording instruments for pressure, vacuum, liquid level, differential pressure, temperature, electricity, time, motion, speed humidity, etc. at the Panama-Pacific International Exposition, at San Francisco. This exhibit (Fig. 1) is located in the

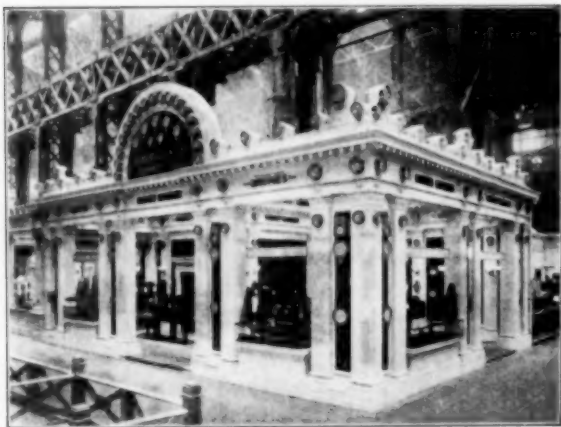


FIG. 1—INSTRUMENT EXHIBIT

Palace of Machinery in section 22. The decoration of the superstructure of the booth are actual models of Bristol recording instruments.

On the lower part of the outside columns of the booth actual working models of Bristol Instruments are exhibited in operation, producing records of atmospheric temperature, the level of the tide in the bay, over a distance of several hundred feet, electrically, also records of conditions on the electrical circuits of the Palace of Machinery, including volts and cycles, or frequency,

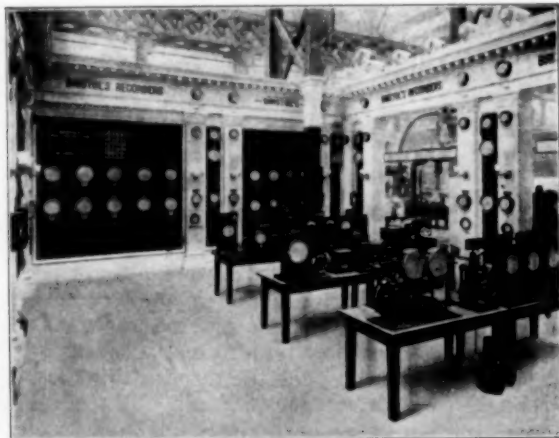


FIG. 2—INSTRUMENT EXHIBIT

record of the water pressure in the mains of the Palace of Machinery, and records of the operation of a series of signal switches provided for the visitor to manipulate at will.

Inside the booth, an interior view of which is shown in Fig. 2, more than 100 complete working models of the Bristol recording instruments are mounted on walls and tables, and of these instruments quite a number are arranged in the form of demonstration outfits which can be operated by hand by the visitor.

For instance, a hand-operated generator is provided for lighting a series of lamps and mounted with it is a Bristol recording voltmeter, an ammeter, and a wattmeter, recording simultaneously the voltage and the

amperage as well as the wattage on these lamp circuits.

Another interesting demonstration outfit is a pair of the new Bristol long-distance electric thermometers by means of which the visitor is shown how the temperature of his own hand could be indicated automatically on an instrument 50 miles away from the point at which the temperature is measured.

The instruments in many demonstration outfits are shown with glass fronts, or without covers, making it possible for the visitor to see the simple internal construction, and to study the principles of operation.

### Electric Steel in Germany and Austria

The following latest figures on the use of the electric furnace for steel refining and reduction and production in Germany and Austria during 1914 should be of considerable interest.

The total production of electric steel in Germany in 1914 was 89,336 tons. Of these 44,080 tons or 49.34 per cent were produced in furnaces of the three types controlled by Siemens & Halske, as follows: 34,393 tons or 38.50 per cent in induction furnaces, 7437 tons or 8.32 per cent in Girod furnaces, and 2250 tons or 2.52 per cent in radiation furnaces.

In 1914 there were twenty electric steel plants in operation in Germany, not including electric furnaces for melting ferromanganese. Of these twenty plants ten used furnaces controlled by Siemens & Halske, as follows: Six plants have only induction furnaces, two have induction furnaces and Girod furnaces, one is equipped with only Girod furnaces, and one with radiation furnaces only.

The other ten electric steel plants used furnaces not controlled by Siemens & Halske, as follows: Seven use Heroult furnaces, two Nathusins furnaces, and one Keller furnaces.

Plants which contemplate building new electric furnaces are not included in the above figures.

Of all the above-mentioned twenty electric-furnace plants eight use the electric furnace for making high-grade electric steel to supplant crucible steel. Of these plants four use only induction furnaces, two induction furnaces and Girod furnaces, and two Heroult furnaces.

The total amount of crucible steel and electric steel produced in Germany in 1914 was 184,432 tons, of which 95,096 tons or 51.6 per cent were crucible steel and 89,336 tons or 48.4 per cent electric steel. *Electric steel has therefore now reached practically the same commercial importance as crucible steel in Germany.*

Twelve plants using electric furnaces for melting ferromanganese were in operation in Germany in 1914. Six of these plants used Siemens & Halske furnaces namely, induction furnaces (four plants), Rombach furnaces (one plant), and Girod furnaces (one plant). In the other six plants Heroult furnaces are used in three plants, the Nathusins furnace in one plant and the Keller furnace in two plants.

The production of electric steel in Austria-Hungary in 1914 was 19,844 tons. Of this amount 9037 tons, or 45.54 per cent, were produced in induction furnaces. The production of electric steel made in Girod furnaces cannot be specified as these furnaces are also used in plants operated by the Government. The production of electric steel made in Siemens & Halske furnaces is, however, over 50 per cent of the total production.

The total amount of crucible steel and electric steel made in Austria-Hungary in 1914 was 37,401 tons, of which 19,844 tons or 53.1 per cent were electric steel and 17,557 tons or 46.9 per cent were crucible steel. *That is, Austria-Hungary now produces more electric steel than crucible steel.*



## An Important Advance in Gas Producer Efficiency

The "Producer-Gas Machine," built by the Morgan Construction Company of Worcester, Mass., represents a radically new departure in gas producer design, and the results obtained thereby mean a very important

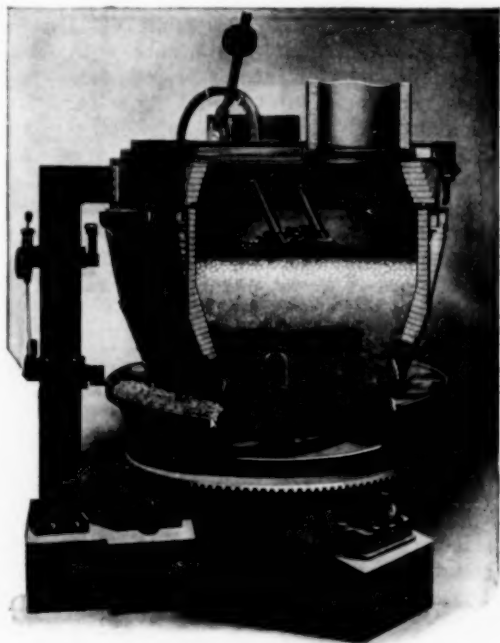


FIG. 1—GAS PRODUCER MACHINE

advance in efficiency of operation. Heretofore it has been an axiom of gas producer design that it is necessary to poke or otherwise break up the fuel bed. The Morgan producer-gas machine is based upon the opposite principle—namely, that the fire must not be disturbed, that it is far better to leave it alone, provided certain essential conditions are fulfilled. These conditions are that the coal be properly spread and the surface be properly leveled, that the ash be removed without producing an uneven fuel bed, that small quantities of coal be regularly and continuously fed to the producer, and that all these functions be performed by continuous mechanical means without hand labor.

The reason for the effectiveness of leaving the fire alone is that every disturbance of the body of the fuel causes variations of density which create local hot places and, in consequence, poor gas and clinkers. To have a uniform, even, quiet fuel bed, two conditions must be fulfilled. First, the top surface must be continually levelled; this is done, as shown in the illustrations, by the leveller which floats on the fuel, permits any practicable variation in height, and is quickly and easily replaced through the top. Second, the removal of the ash must be carried out in such a way as not to make the fuel bed uneven. For this reason, it is a mistake to rely upon sweeping the ash off the edge of the ash support. In the Morgan producer-gas machine the entire bottom of the ash pan is swept by a spiral-shaped bar or plow, the result being a uniform settling of the ash over the entire area. The plow is simply held stationary by the setting of a lever, while the machine makes one complete revolution, which requires fifteen minutes, and is usually

sufficient to discharge the ash made in twelve hours. The release is automatic.

Regular continuous feeding of small quantities of coal requires the abolition of manual charging. The feeding device receives the coal from the bin and charges it in small and uniform quantities at frequent intervals *without manual action*. A result of the development of this feeder, acting together with the coal leveller and ash plow, is that one man can tend a battery of six machines gasifying four times as much coal as is possible for one man in any previous construction.

While practically all known types of mechanical gas producers, having a gas-making surface of 10 feet diameter, operate at an average rate of not over 1600 to 1700 lbs. of coal per hour while yielding gas averaging about 145 B.T.U. per cubic foot from Pittsburgh coal, the 10-foot Morgan producer-gas machine converts 3000 lbs. of the same coal per hour, into gas yielding 178 B.T.U. per cubic foot. This is an advantage of over 50 per cent in capacity, combined with 20 per cent advantage in quality.

Before giving further results from actual practice, a few words should be said concerning some minor, though important details of design. The even distribution of the blast over the entire gas-making area would

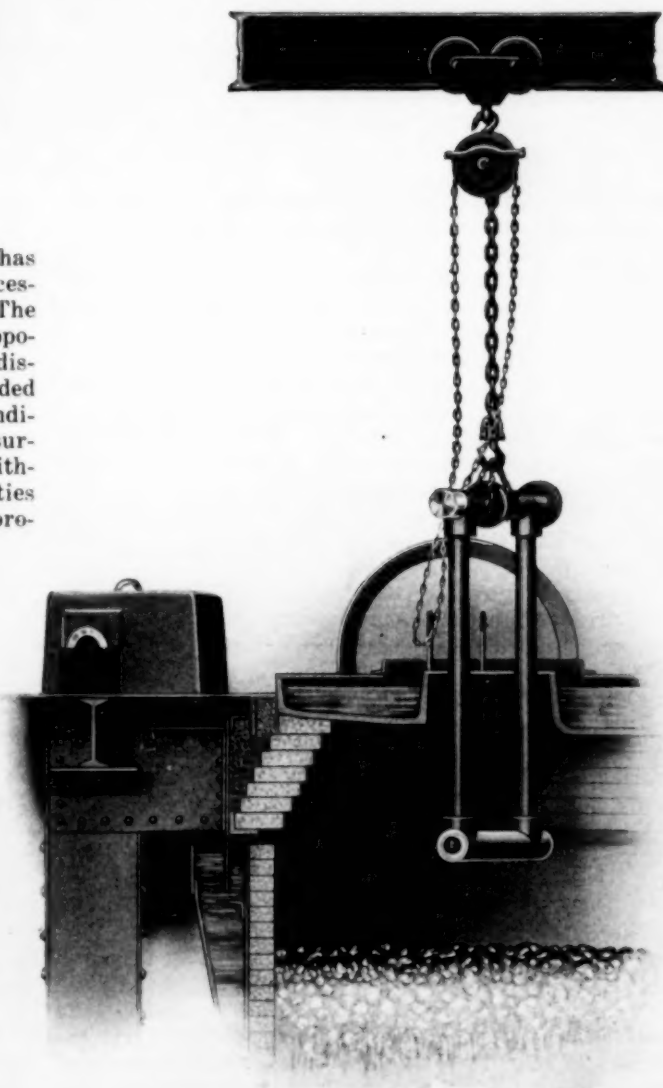


FIG. 2—REMOVING THE FUEL LEVELLER

(Under normal conditions the water-cooled bar lasts about one year unless the water is shut off for several hours. It can be changed in twenty minutes.)

be impossible with a central blast hood for a gas producer of such high capacity. In the Morgan machine the blast is delivered from three hollow radial arms and around the whole circumference of the hollow ring or mantel shown in the illustration. The result is a gentle sustained pressure evenly distributed over the whole surface.

The question of fire-brick lining has also been given unusual attention. To prevent the inner surface of the bricks from fusing with the ash from the coal so that large clinkers would attach themselves to the wall, the thickness of the fire-brick is reduced and it is surrounded with a water-jacket which keeps it cool enough on the inner surface to prevent any slagging action with the ash, but without appreciably reducing the temperature of the burning fuel adjacent to the wall.

As to the composition and the calorific value of the gas produced, the results obtained with one of the first Morgan producer-gas machines by a large steel company are interesting. Twelve-hour samples of the gas were taken day and night for several weeks. They show the great uniformity of the gas. For instance, the CO<sub>2</sub> content in the 11 analyses made during one week, had the values 3.0, 3.2, 2.8, 3.0, 2.5, 2.7, 2.7, 3.0, 2.5, 2.9, 3.0 (average 2.8). The CO content 26.3, 25.4, 28.7, 27.8, 29.2, 26.7, 26.9, 27.5, 27.2, 28.6, 26.7 (average 27.4).

The average values of the analyses for one week were as follows, the corresponding values for the following week being given for comparison in parentheses: CO<sub>2</sub>, 2.8 (2.8); C<sub>2</sub>H<sub>4</sub>, 0.6 (0.6); CO, 27.4 (27.3); H<sub>2</sub>, 11.4 (11.1); CH<sub>4</sub>, 3.6 (3.4); B.T.U. at 32 deg. F., 182.5 (179.0). During part of the time these analyses were made an accurate account of the quantity of coal gasified was kept. The average was 2766 lbs. coal per hour for 120 hours with gas of 178 B.T.U.

At another plant operating open-hearth furnaces eight-hour continuous samples of the gas were analyzed practically every day. The records, covering a period of five months, average 3.5 per cent CO<sub>2</sub>, 28.8 CO, and 182 B.T.U. (at 32 deg. F.).

Recently the same plant desired to determine on what gasifying capacity they could safely count as a guide for their future requirements. After increasing the rate to 3260 lbs. coal per hour with every indication that it could be further increased, they decided that they could safely rely on a working capacity of 3000 lbs. per hour, without the quality of the gas suffering at the higher capacity.

The above figures are of significance if compared with best present practice, as a gas averaging 25 per cent CO and a calorific value of 160 B.T.U. per cu. ft. (total at 32 deg. F.) are considered the very best results at present attainable.

Further details of extensive service tests with illustrations of details of design and construction may be found in a new catalog which the Morgan Construction Company of Worcester, Mass., is publishing.

### Drop Forged Parts as a Substitute for Brass Castings

The development of a new alloy, placed on the market under the name of "titan bronze," makes it possible to manufacture drop forged bronze parts in place of brass castings. The Titan Metal Company, 1124 Real Estate Trust Building, Philadelphia, control the process of manufacturing the metal, and have granted an exclusive license for the manufacture of finished castings and casting ingots to the Alpha Metals Company, Bellefonte, Pa.

Titan bronze has a high tensile strength, ranging from 75,000 to 85,000 lbs.; an elastic limit of 40,000 to

48,000 lbs.; reduction of area, 45 per cent to 50 per cent, and elongation 22 per cent to 30 per cent, making it possible to use it in many places where steels have been used and where bronze would have been preferable, with the added advantage of its non-corrosive qualities. This point is of particular interest to the chemical and metallurgical industries.

Titan bronze can be worked hot and is valuable for making drop forgings to supersede certain forms of castings and on account of the ease with which it is worked its introduction into practice is expected to have a great effect on hot press work from bars or sheets, hot rolled thread bolts, cap-screws, wood screws, gears, pinions, ship and bolt fittings, and a large number of uses where steel has been utilized with expensive machine operations to produce the finished article.

A valuable application of titan bronze is in form of bronze-covered iron and steel sheets suitable for a wide variety of uses to resist corrosion in various lines of manufacture.

### The Preparation of Metal Specimens for Metallographic Tests

To the inexperienced, the tedium of preparing the specimens has often been a barrier to the acquirement of a working knowledge of metallography. Any scientific work may be made difficult and unattractive by the use of crude or cumbersome appliances. While polishing metallographic specimens is a delicate operation, it is not difficult if a few simple precautions are ob-

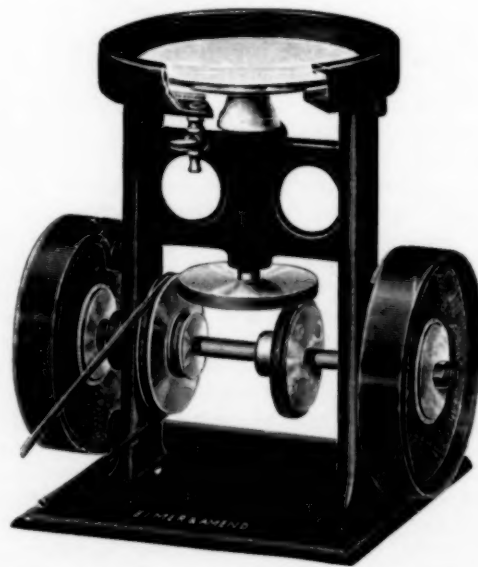


FIG. 1—GRINDING AND POLISHING MACHINE

served. The procedure must, of course, differ somewhat with the character of the metal.

Messrs. Eimer & Amend, 18th Street and Third Avenue, New York City, have recently placed on the market the Wysor combined grinding and polishing machine which facilitates greatly the preparation of the metal specimens. It is suitable for hard metals and alloys in general, but it is designed especially for the treatment of iron and steel.

It comprises two machines in one, though quite simple in construction. As shown in Fig. 1, a one-piece casting forms the base and frame upon which all the parts are mounted. The grinding wheels are of carborundum, and are carried on the horizontal or driving shaft, the roughing wheel being on one end and the medium and finishing wheels on the other end. The



polishing discs are of brass with cloth coverings, and are easily replaceable on the head of the vertical spindle. This is driven by contact with a friction wheel on the horizontal shaft. It is disengaged when not in use, or when discs are to be exchanged, by means of a cam attached to the frame. The speed at which the polishing



FIG. 2—BULBS IN TRAY

discs are revolved may be varied by shifting the friction wheel on the shaft. The disc upon which the specimen is first polished after the grinding is covered with canvas, and the powder used is emery flour. The second disc is covered with broadcloth and tripoli powder is used. The third

disc, on which the specimen is finished, is covered with broadcloth, jewelers' rouge being used with this. Separate cases are provided for holding the tripoli and rouge discs when not in use. This insures freedom from grit. Ample protection against flying particles from the wheels is afforded by the cast iron shields. The polishing powders are mixed with water to the consistency of flowing paste, and may be kept in glass bottles from which they are conveniently poured into the glass bulb holders, which are used for applying them to the discs. When filling or shaking, the small opening of the bulb is closed by pressure of the finger, and when filled the large opening is closed with a tightly fitting rubber stopper. The three bulbs for the pastes and a fourth for clear water are held conveniently on a wooden tray as shown in Fig. 2.

### Sprays for Cooling Water

The Spray Engineering Company, 93 Federal Street, Boston, Mass., has placed on the market a new spray nozzle, the design of which is shown in Fig. 1. It is provided with a removable turbine center which has large passageways. The center is held stationary in the nozzle so that there are no moving parts to wear out. The water, in passing through, is given a rapid rotating motion. A central driving jet, which impinges on the rotating water at the orifice, causes the water to be ejected as a fine, dense, uniform spray.

These nozzles are operated at a low pressure. The central driving jet, which is a particular feature of this design, fills in the center of the spray, thus giving it a solid (instead of hollow) conical formation.

One of the principal applications is for **spray cooling ponds**, and for this purpose the arrangement of the sprays is next in importance to the design of the nozzle. As seen in Fig. 2, which shows the spray cooling pond of the Erlanger Cotton Mills, of Lexington, N. C., the nozzles are arranged in groups and are so inclined toward opposing nozzles that when the sprays are operating they are made to collide with each other. By reason of this collision the drops of water are broken into much finer particles than could be effected by the action of the nozzles alone. For it is evident that the finer the spray the greater will be the cooling effect.

Natural ponds without sprays require about fifty times more area than the spray cooling system and in the summer seldom cool the water sufficiently. When water is scarce or insufficient for fire protection a spray pond offers a good source of supply. It is customary to connect the fire pumps direct with the pond.

The cooling of the water is effected in three ways: by evaporation, by radiation, and by convection. That

is, heat is abstracted from the water equal to the latent heat of evaporation of the amount of water which evaporates; secondly, heat is radiated from the sprays to the cooler surroundings; and thirdly, heat is carried away by the surrounding air currents by convection.

Those spray cooling ponds are of great usefulness wherever water has to be cooled for condensers, transformers, or water jackets. With the introduction of steam turbines better vacuum and, therefore, colder condensing water have become a necessity. A 26-in. vacuum requires condensing water not over 103 deg. F., a 28-in. vacuum not over 80 deg. F. By the use of the spray

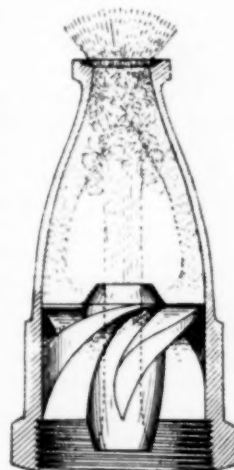


FIG. 1—SPRAY NOZZLE

system it is possible to obtain an average vacuum of 28 in. the year round in almost all parts of the United States.

A second application of the spray system is for **washing and cooling air**, for instance, for turbo-alternators. The design and construction of the spray turbo air washer are such that every particle of air passing through the machine is forced into intimate contact with fine particles of water from spray nozzles. To insure the complete removal of any dust particles which may have passed through the first set of sprays in the air washer the air is again subjected to the action of cross-scrubbing sprays placed beyond the first set of sprays. The air is next passed through a screen,

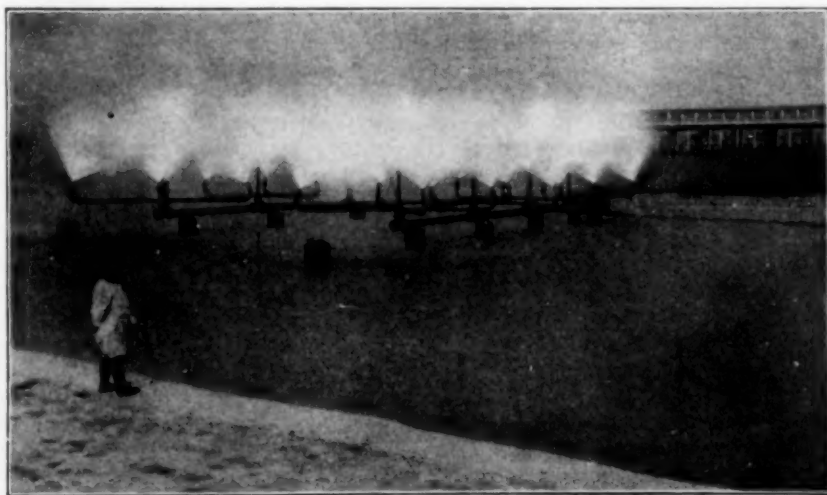


FIG. 2—SPRAY COOLING POND AT ERLANGER COTTON MILLS, LEXINGTON, N. C.

which removes a large part of the entrained water and prevents any large stratum of air from passing through the washer without coming in contact with wet surfaces. All free moisture in the air is then removed by eliminator plates, the air leaving the washer clean and dry, but with a relative humidity of 100 per cent.

### Personal

Mr. H. G. S. Anderson, formerly with the Buffalo Company, at Cobalt, and more recently in Mexico, stopped in Denver on his way to Nevada on professional business.

Mr. Will H. Coghill has removed to El Paso, where he will continue his work as consulting metallurgical engineer.

Mr. J. C. Daley, electrical and designing engineer for the Thordarson Electric Mfg. Company, Chicago, has severed his connections with that company and joined with Mr. J. A. Bennan and Mr. A. R. Johnson in the incorporation of the Jefferson Electric Mfg. Company. The new company is already located and doing business at 847-851 W. Harrison Street, Chicago, manufacturing a complete line of toy, bell ringing, sign lighting and welding transformers, battery switches, steel battery box outfits, make and break and jump spark igniton coils, and a line of high-tension transformers for testing, laboratory and research work.

Mr. J. V. N. Dorr spent part of the month of May at the Denver office of the Dorr Cyanide Machinery Co., having previously been farther West on professional business.

Mr. A. E. Guy, chief engineer of the pump department of the Providence Engineering Works, lectured in Denver recently on the History and Development of Centrifugal Pumps. Mr. Guy has been in charge of the pumping installation on the Penrose shaft in the downtown district of Leadville.

Mr. H. W. Hardinge has left New York for a six weeks' trip to the West and Alaska.

Mr. James M. Hyde, of San Francisco, has gone to New York on professional business.

Mr. Bradley Stoughton, secretary of the American Institute of Mining Engineers, is visiting western mining centers and has been the guest of honor at luncheons and dinners given by various sections of the Institute.

Mr. Pope Yeatman is in Chile inspecting the copper leaching plant at Chuquicamata, which is expected to be put in operation this month. He is expected to return to New York about the end of June.

The following changes in the technical staff of the International Smelting & Refining Co., at Tooele, Utah, were made effective May 1. A. B. Young, formerly in charge of the testing plant, is superintendent of blast furnaces. He is succeeded in the testing plant by B. L. Sackett, formerly chief chemist. Carlos Bardwell is the successor of Mr. Sackett.

### Notes

The German Potash Syndicate has authorized the following deliveries of potash for domestic and foreign consumption during 1915 when the embargo is removed. This will enable consumers to know the amount available. Plans for denaturizing potash salts, so that the embargo can be raised, have not as yet materialized.

Kinds of potash	Metric tons of pure potash, $K_2O$	
	Domestic	Foreign
Carnallite with at least 9 and less than 12 per cent $K_2O$ .....	4,800	300
Raw salts with 12 to 15 per cent $K_2O$ .....	266,600	82,200
Fertilizer salts with 20 to 22 per cent $K_2O$ .....	2,000	33,400
Fertilizer salts with 30 to 32 per cent $K_2O$ .....	3,600	11,500
Fertilizer salts with 40 to 42 per cent $K_2O$ , including potash fertilizer with 38 per cent $K_2O$ .....	229,200	68,700
Potassium chloride .....	54,500	138,300
Potassium sulphate with more than 42 per cent $K_2O$ .....	1,200	37,600
Potassium-magnesium sulphate .....	200	14,700
Total .....	562,100	386,700

**New Gas Works.**—Under the title "Interesting Installations, Philadelphia," the Improved Equipment Company of New York City has issued a profusely illustrated little pamphlet describing the improvements made by the United Gas Improvement Company at its Point Breeze works in Philadelphia. They included the installation of five benches of mines. These are the Improved Equipment Company's No. 8 benches of mines—21'-0" thrus—equipped with the Doherty bench fuel economizer and having sectional silica retorts and settings. The illustrations in the pamphlet show the construction in the course of progress.

An electric steel furnace installation of considerable interest is being made in Detroit, Mich., by the John A. Crowley Co. While the details are not as yet given out it will be a six-ton unit of the Grönwall type, which has been used successfully by Sheffield, England, mills for producing high-grade steels and difficult castings. This will be the first installation of this type of electric furnace in this country and it was expected to be put into operation during May. The furnace operates on a two-phase circuit, with two electrodes, each phase being connected to one of the electrodes, the circuit being completed through a neutral pole embedded under the lining of the hearth. This method carries the current through the bath and causes sufficient motion of the molten metal to effect uniform heating and complete distribution of any alloys that may be added, which together with the characteristic non-oxidizing atmosphere insures the production of sound castings of the exact compositions. The design of the Grönwall furnace was described in some detail in an article in our vol. IX, page 573 (November, 1911).

An antimony smelter is in course of erection in the city of San Luis Potosi, Mexico, according to Consul Wilbert L. Bonney. It will be ready for operation when mining and transportation conditions permit ore to be produced and the product shipped. The machinery, which is American, is now ready for installation. It is expected that the plant will employ 150 men and the capacity is to be 3000 tons per annum of refined star antimony. The product will be shipped to the United States. This will be the first and only smelter in Mexico producing refined antimony for the market. It is owned by American capital and will draw ores from its own properties in San Luis Potosi and Queretaro.

The only antimony smelter heretofore operating in Mexico is located at Wadley, a small station on the National Railway, 102 miles north of San Luis Potosi. The Wadley smelter is not equipped for finishing the product, and has exported its product to England for further refining. The Wadley plant was erected about 14 years ago, and has drawn a large part of its ore from the Catorce district.

Chilean nitrate statistics reported by Consul D. J. Myers show a marked decrease in production. In November, 1914, the output was 2,659,875 quintals (of 101.6 lb.) compared with 4,885,869 quintals in November, 1913. Fifty-four plants were working in November, 1914, compared with 127 in the same month of 1913. Government loans to nitrate companies up to November 30, 1914, amounted to 25,836,207 paper pesos (value from 15 to 20 cents per peso). Exports from July 1 to November 30 showed a decrease of 13,000,000 quintals under the corresponding period of 1913.

Tin exports from Bolivia in 1914 were seriously restricted by the war, particularly during the last three months of the year, when the decrease amounted to 36 per cent of the average monthly shipments. The rise in price has partly compensated the loss in tonnage. The shipments for the year are estimated at 34,624 metric tons.



**Tin output of the Federated Malay States in 1914** fell short of that for 1913, being only 109,854,533 lb., a decrease of 2,429,333 lb. The decrease in value was \$2,048,620 U. S. gold. The offer of the local government to buy the total tin output at a price of \$34.05 per picul (133 1-3 lb.), averted a crisis in the community, as the European war had effectually restricted the market.

**Analysis of Brazilian monazite sand** by F. H. Lee, of the Geological Service of the Brazilian Government, shows 29.28 per cent  $P_2O_5$ ; 31.28 per cent  $Ce_2O_3$ ; 30.88 per cent  $La_2O_3$  and  $Di_2O_3$ ; 1.40 per cent  $SiO_2$ ; 6.49 per cent  $ThO_2$ ; 0.20 per cent loss on ignition; total 99.53 per cent. The average thorium oxide content of the marketed product ranges from 6.2 to 6.4 per cent. The following table shows the exports of monazite sand from Brazil from 1905 to 1913.

Years and countries	Metric tons	Value
1905	.....	\$485,184
1906	.....	480,843
1908	.....	157,475
1909	.....	708,092
1910	.....	631,251
To United States	1100	130,650
To Germany	2636	303,953
To France	1691	195,466
1911	.....	539,299
To United States	700	101,352
To Germany	1890	280,996
To France	1096	156,961
1912	.....	527,268
To United States	600	93,197
To Germany	1852	291,467
To France	945	142,604
1913	.....	186,478
To United States	400	51,905
To Germany	256	33,181
To France	778	101,003

**The Anaconda Copper Mining Co.** expects to have its new copper refinery at Great Falls ready for operation by January, 1916. The capacity will be 10,000,000 pounds of copper per month. The work of construction will be in charge of J. H. Klepinger, superintendent, and Peter Thill, master mechanic. The company recently announced that it would ship copper from Montana via Tacoma, Wash., and the Panama Canal to New York. The routing shows economy over present all-rail shipment to the Atlantic seaboard, and the experiment will be tried to see what the actual result will be.

According to the annual report of the **Portland Gold Mining Co.**, Colorado, for 1914, the net earnings were \$590,595. The mine produced 62,997 tons of ore which was shipped to the high-grade mill at Colorado City. The average grade was \$23.42 per ton. The low-grade mill at Victor treated 210,132 tons of ore, of which 18,934 tons came from the mine and 191,198 tons from the dump. Dividends paid during the year amounted to \$360,000. No statement is made regarding milling costs or recoveries.

**The iron industry of Brazil** is comprised in one furnace with a capacity of about 15 tons per day, situated at Esperanca. The plant has been operated for about 10 years, and has recently been rebuilt and enlarged.

**Branch laboratories of the Bureau of Standards** are maintained at Northampton, Pa., and Pittsburgh. The former is devoted to the sampling, testing and certification of cement, and the latter to investigations and tests of structural engineering and miscellaneous materials.

**The prospectors' short course** offered this spring by the Mackay School of Mines, Reno, Nev., and the Colorado School of Mines, Golden, Colo., was very successful. The attendance at Nevada was 25 and at Colorado 49. The courses evidently meet a need among men engaged in prospecting but who are without much technical education.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

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### Aqueous Rath, Anodes

82,877, October 6, 1868, William H. Remington, of Boston, Massachusetts, assignor to himself, Sarah A. T. Peabody and George D. Allen.

Relates to anodes for electroplating, and describes suspending nickel particles in a platinum basket or woven-wire receptacle; also lining a vat with carbon, connected to the anode, and covering the carbon bottom with nickel particles; also inserting a carbon shelf, or shelf of other suitable conductor not acted on by the solution through a side of the vat and placing the nickel particles on the shelf; also electroplating carbon or other conductor with nickel, and using the composite conductor as an anode. The electrolyte preferred is made as follows: Nitric acid, to which is added about one-twentieth part water, is saturated with nickel, the latter is then precipitated by the addition of carbonate of potash. The precipitate is then washed with pure water and then dissolved in a strong solution of sal-ammoniac, and filtered. It is then ready for use.

129,881, July 30, 1872, George W. Beardslee, of Brooklyn, New York.

Relates to an electrode for electrodepositing metals, and consists of a plate of carbon, platinum, or other conductor that is insoluble in the electrolyte, inclosed in a cover of mosquito-netting or similar very loosely-woven fabric, the fabric holding a layer of granular or fractured metal to be electrolytically dissolved and deposited upon the article to be plated, against each side of the carbon electrode, the whole being supported in a frame of wood or other like material.

155,884, October 13, 1874, Pierre Adolphe Normandeau, of Brooklyn, E. D., New York.

Relates to receptacles for holding granules or fragments of metal to serve as anode, the receptacle being rigid in form and consisting of a flat casing with perforated walls and an open upper end, and preferably made of gutta-percha, or similar material. It is suspended by hooks of insulating material. A conductor of platinum or silver is secured to the inside of the receptacle and contacts with the metal to be dissolved.

166,367, August 3, 1875, August Hermann and Warren H. Taylor, of Stamford, Connecticut.

Relates to anodes for electroplating, and consists preferably of a carbon plate having imbedded in its surface, while the carbon mass is still plastic, a number of nickel granules, or fragments of nickel anodes. If a platinum plate is used the granules are secured to the platinum by shellac, glue, or other suitable adhesive substance. See the reissue of this patent, No. 7,489, dated February 6, 1877.

166,433, August 3, 1875, Edward Weston, of New York, N. Y., assignor to Stevens, Roberts and Havell, of Newark, New Jersey.

Relates to an anode in which particles of metal or an oxid, carbonate, or other compound thereof, or metallic dust, is mixed with a cement such as powdered carbon and molasses, or some other substance capable of forming a coherent paste. The mass thus obtained is placed in molds and subjected to pressure, dried, and then baked out of contact with air until the mass is thoroughly carbonized, and a solid, compact, coherent mass is obtained. When nearly exhausted of metal by use, the residue may be ground up and mixed with a fresh mass for a new anode.

Reissue 7,489, February 6, 1877 (original 166,367), August Hermann and Warren H. Taylor, of Stamford, Connecticut, assignors, by mesne assignments, to the Yale Lock Manufacturing Company, of same place.

Relates to anodes for electroplating, and consists preferably of a carbon plate having imbedded in its surface, while the carbon mass is still plastic, a number of nickel granules or fragments of nickel anodes. If a platinum plate is used the granules are secured to the platinum by shellac, glue, or other suitable adhesive substance.

208,003, September 10, 1878, Adolph C. Wenzel, of Brooklyn, New York.

Relates to a receptacle for holding grain nickel or other metal for use as an anode in electroplating. The receptacle consists of two carbon or graphite plates, perforated with many fine holes, and separated by a U-shaped carbon or graphite separator, the plates and separator being united by hard-rubber bolts. The receptacle is supported by a clamp carrying a hook by which it is suspended from a conductor above the plating tank. The grain nickel is placed in the receptacle, and makes contact through the carbon sides thereof.

223,265, January 6, 1880, Joseph Wharton, of Philadelphia, Pennsylvania.

Relates to nickel anodes for electroplating and consists of a wrought, rolled, or hammered cast plate of nickel, the physical condition of the malleable metal effecting a greater economy in use than that obtained with the granulated metal.

226,576, April 13, 1880, Abraham Van Winkle, of Newark, New Jersey.

Relates to anodes for electroplating and consists in a frame surrounding the side and bottom edges of a rolled or plate anode, for the purpose of preventing pieces that may be dissolved loose from falling to the bottom of the tank.

### Book Reviews

**Industrial Chemistry.** By Rogers and Aubert. Second Edition. Edited by Allen Rogers in collaboration with many specialists. 1005 pages, 305 illustrations. Price \$5.00 net. New York: D. Van Nostrand Company.

The publication of this second thoroughly revised and enlarged edition is timely. No such opportunity as that presented to-day has come before the chemists of this country for a fuller development of our natural resources. The work deals with American practice, and from the fact that the present edition has the imprint "fifth thousand" we learn that it has been appreciated.

The range of subjects is wide. The topics are treated of by men having experience in more fields than those they write of, and so a broader view of each subject is given. Ten new chapters have been added, recognizing the newest features in chemical progress. One cannot but be impressed with the constructive work now being done by the professional chemists in comparison with the older type of analysts. As the work widens better conditions will obtain and young men will be attracted to chemistry as a life work. This volume will undoubtedly be the means, in many instances, of creating interest among students and manufacturers in chemical problems. Heretofore their interest has been largely in mechanical devices and methods. Abundant references to special treatises are given at the end of each chapter. Particular pains have been taken to make the principles involved in each manufacture clear. Often several different methods of carrying out a chemical reaction are given. There are diagrams illustrating the flow of material from the raw state to the various

finished products, and schematic plans of apparatus give clear conceptions of what the several processes are intended to accomplish. There are also abundant illustrations of plants and of apparatus.

The practical part of the book is excellent and most creditable to the publishers.

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**The Cyanide Handbook.** By J. F. Clennell. Second edition, octavo, 602 pages, illustrated; price \$5.00. New York: McGraw-Hill Book Company.

This is a *vade mecum* for assayers, chemists, foremen and managers of cyanide plants, giving all the details of chemical and physical principles and practice utilized in the operation of such plants. It is an eminently practical book, written in the true scientific spirit by a scientifically practical man.

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**How to Build Up Furnace Efficiency.** A handbook of fuel economy. By Jos. W. Hays. 126 pages, illustrated. Seventh edition. Price \$1. Chicago: Jos. W. Hays.

This a popularly written little treatise discussing in five chapters why fuel is wasted, how it is wasted, how to "spot" fuel waste, how to stop it, and how to keep the waste stopped.

The book is intentionally written in a popular style and anecdotes are liberally used for purposes of illustration, for the author's thesis is that the men to stop the fuel waste are the men who are doing the wasting—the practical firemen. Their interest must be aroused and kept. The author emphasizes that just as all practical men know how to use thermometers and scales, so they can be shown how to use draft gages and gas analyzers, even if they don't understand the theory.

The book is well written for the purpose for which it is intended and should do much good.

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**Analysis of Alloy Steels. Methods of the Chemists' Committee of the United States Steel Corporation.** 70 pages. Price \$1. Copyrighted by J. M. Camp, Carnegie Steel Company, Pittsburgh, Pa.

This pamphlet prepared under the direction of the Chemists' Committee of the United States Steel Corporation (J. M. Camp, chairman) on the Sampling and Analysis of Alloy Steels, is now being distributed to its various chemical laboratories. This makes the fifth pamphlet so distributed, whose purpose is to unify and simplify methods of analysis. The other four pamphlets, with their date of issue, cover the Sampling and Analysis of Cases, 1911: Pig Iron, 1912: Ores, 1914 (second edition) and Plain Steel, 1914. To curtail the numerous requests for these pamphlets a charge is now made of \$1 each to persons and firms outside the corporation.

The pamphlet covers both sampling and analysis of alloy steels. Methods for the determination of carbon, manganese, phosphorus, sulphur, silicon, tungsten, chromium, vanadium, nickel, cobalt, copper, molybdenum, aluminium and titanium are given.

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**Joplin News Herald's 1915 Zinc and Lead Handbook.** By L. L. Wittich. 60 pages. Price 25 cents. Joplin, Mo.: Joplin News Herald.

This is the first edition of a little statistical handbook which is intended to be published annually. To those interested in zinc and lead statistics it should prove interesting and useful. Besides data on zinc and lead production in the world and in the United States, on imports and exports, on consumption, on weekly prices of zinc and lead ores during 1914, etc., it contains very full information on the activity of the Missouri-Kansas-Oklahoma district.